RIO GRANDE SILVERY MINNOW RECOVERY PLAN

(*Hybognathus amarus*)

FIRST REVISION

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Southwest Region
U.S. Fish and Wildlife Service
Albuquerque, New Mexico

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Region 2

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Rio Grande Silvery Minnow Recovery Team

Technical Subgroup
Robert J. Edwards, University of Texas-Pan American, Team Leader
Chris Altenbach, City of Albuquerque
Robert Dudley, Senior Research Associate, Museum of Southwestern Biology, Division of Fishes, University of New Mexico
Gary P. Garrett, Texas Parks and Wildlife Department
Champe B. Green, U.S. Army Corps of Engineers
Sterling Grogan, Middle Rio Grande Conservancy District
C. Nicolas Medley, New Mexico Interstate Stream Commission
John Pittenger, Blue Earth Ecological Consultants/Amigos de Bravos
Steven P. Platania, Associate Curator, Museum of Southwestern Biology, Division of Fishes, University of New Mexico
Michael Porter, U.S. Bureau of Reclamation/U.S. Army Corps of Engineers
David L. Propst, New Mexico Department of Game and Fish
Nik Zymonas, New Mexico Department of Game and Fish

Tribal Subgroup
Lawrence Abeita, Bureau of Indian Affairs – Southern Pueblos Agency
Joe Jojola, Bureau of Indian Affairs – Regional Office
Norman Jojola, Bureau of Indian Affairs – Northern Pueblos Agency
John Sorrell, Pueblo of Isleta
Cody Walker, Pueblo of Isleta
Alex Puglisi, Pueblo of Sandia
Brian Bader, Pueblo of Santa Ana
Ben Chavarria, Pueblo of Santa Clara
Joseph Chavarria, Pueblo of Santa Clara
Jason Garcia, Pueblo of Santa Clara
Gilbert Guiterrez, Pueblo of Santa Clara
Jeffery Lyon, Pueblo of Santa Clara
Leif Bang, Pueblo of Santo Domingo
Gabriel Cosyleon, Pueblo of Santo Domingo
Boyd Nystedt, Pueblo of Santo Domingo
Lawrence Cata, Pueblo of Ohkay Owingeh
Charles Lujan, Pueblo of Ohkay Owingeh

Participation Subgroup
Julie Hall, U.S. Army Corps of Engineers
Chuck Hayes, New Mexico Department of Game and Fish

Lori Robertson, U.S. Bureau of Reclamation
Rolf Schmidt-Peterson, New Mexico Interstate Stream Commission
Herman Settemeyer, Texas Commission on Environmental Quality
Subhas Shah, Middle Rio Grande Conservancy District
Bryan Shields, Amigos Bravos
John Stomp, City of Albuquerque
Mike Sullivan, Colorado Office of the State Engineer
Steve Vandiver, Colorado Office of the State Engineer

U.S. Fish and Wildlife Service Liaison to the Recovery Team
Jennifer M. Norris, Ph.D.

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EXECUTIVE SUMMARY

Current Status of the Species

The Rio Grande silvery minnow was listed as federally endangered in 1994 (59 FR 36988) and critical habitat was designated in 2003 (68 FR 8088). The Rio Grande silvery minnow historically occupied approximately 3,862 river km (2,400 mi) in New Mexico and Texas. It was found in the Rio Grande from Española, New Mexico, through Texas to the Gulf of Mexico (Bestgen and Platania 1991). It was also found in the Pecos River, a major tributary of the Rio Grande, from Santa Rosa, New Mexico, downstream to its confluence with the Rio Grande in Texas.

Currently, the Rio Grande silvery minnow is known to occur only in one reach of the Rio Grande in New Mexico, a 280 km (174 mi) stretch of river that runs from Cochiti Dam to the headwaters of Elephant Butte Reservoir. This includes a small portion of the lower Jemez River, a tributary to the Rio Grande north of Albuquerque. Its current habitat is limited to about seven percent of its former range. In December 2008, silvery minnows were introduced into the Rio Grande near Big Bend, Texas as a nonessential, experimental population under section 10(j) of the ESA (73 FR 74357). Preliminary monitoring is being conducted to determine whether or not that reintroduction has been successful.

Habitat Requirements and Threats

The Rio Grande silvery minnow uses only a small portion of the available aquatic habitat. In general, the species most often uses silt substrates in areas of low or moderate water velocity (e.g., eddies formed by debris piles, pools, and backwaters). The Rio Grande silvery minnow is rarely found in habitats with high water velocities, such as main channel runs, which are often deep and swift. The species is most commonly found in depths of less than 20 centimeters (cm) (7.9 inches [in]) in the summer and 31-40 cm (12.2-15.75 in) in the winter. Few use areas with depths greater than 50 cm (19.7 in).

Throughout much of its historic range, the decline of the Rio Grande silvery minnow is attributed primarily to destruction and modification of its habitat due to dewatering and diversion of water, water impoundment, and modification of the river (channelization). Competition and predation by introduced non-native species, water quality degradation, and other factors also have contributed to its decline.

Recovery Goals and Criteria

Three goals have been established for the recovery of the Rio Grande silvery minnow:

1. Prevent the extinction of the Rio Grande silvery minnow in the middle Rio Grande of New Mexico.

2. Recover the Rio Grande silvery minnow to an extent sufficient to change its status on the List of Endangered and Threatened Wildlife from endangered to threatened (downlisting).

3. Recover the Rio Grande silvery minnow to an extent sufficient to remove it from the List of Endangered and Threatened Wildlife (delisting).

Downlisting (Goal 2) for the Rio Grande silvery minnow may be considered when the criteria in have been met resulting in three populations (including at least two that are self-sustaining) that have been established within the historical range of the species and have been maintained for at least five years.

Delisting (Goal 3) of the species may be considered when the criteria have been met resulting in three self-sustaining populations have been established within the historical range of the species and have been maintained for at least ten years.

Recovery Goal 1. Prevent the extinction of the Rio Grande silvery minnow in the middle Rio Grande of New Mexico.

Recovery Objective 1-A. A middle Rio Grande population at a level sufficient to prevent extinction as defined by criteria related to distribution and reproduction, measured through annual monitoring of the population.

Recovery Criterion 1-A-1. Using the standard sampling protocol (Appendix E), and sampling at a minimum of 20 sites distributed throughout the middle Rio Grande in New Mexico, document the presence of Rio Grande silvery minnow (all unmarked fish) at ¾ of all sites, per reach, sampled during October.

Habitat fragmentation has subdivided the extant population into three distinct sub-reaches, and diversions limit genetic exchange to the downstream direction. The presence of silvery minnow in all three reaches demonstrates reasonable certainty that the remaining genetic makeup of the species has been preserved and that the population can withstand a catastrophic event in any one reach.

Recovery Criterion 1-A-2. Annual reproduction in the middle Rio Grande below Cochiti Reservoir, as indicated by the presence of young-of-year at ¾ of all sites, per reach, sampled during October.

Recovery Objective 1-B. A captive population sufficient to prevent extinction.

Recovery Criterion 1-B-1. A captive population of 50,000 to 100,000 fish with a composition and distribution (among facilities) consistent with the recommendations of the Rio Grande Silvery Minnow Genetics Management and Propagation Plan (U.S. Fish and Wildlife Service 2007).

Recovery Goal 2. Recover the Rio Grande silvery minnow to an extent sufficient to change its status on the List of Endangered and Threatened Wildlife from endangered to threatened (downlisting).

Demographic Criteria:

Recovery Objective 2-A. Three populations, including a stable middle Rio Grande population and at least two additional populations that are self-sustaining (see box p. 3), in the Rio Grande silvery minnow's historical range, as defined by criteria related to population distribution, annual reproduction and extinction risk.

Recovery Criterion 2-A-1. Using the standard sampling protocol (Appendix E), and sampling at a minimum of 20 sites distributed throughout the middle Rio Grande in New Mexico, document for at least 5 consecutive years, an October catch per unit effort (CPUE) from all monitoring sites within each reach of > 5 fish/100 m^2.

Recovery Criterion 2-A-2. Annual reproduction in the middle Rio Grande below Cochiti Reservoir, as indicated by the presence of young-of-year from ¾ of the monitoring sites, per reach, for at least five consecutive years.

Recovery Criterion 2-A-3. Two additional populations of Rio Grande silvery minnow, in the historical range of the species but outside the middle Rio Grande of New Mexico, that each demonstrate (by quantitative analysis) a probability of extinction in the wild of less than 10% within 50 years.

For example, the preliminary PVA developed for the Big Bend reintroduction project suggests that a population that exhibits a long-term lambda of 1.025 will have a lower than 10% probability of going extinct in 50 years. These results assume 5 years of stocking at least 200,000 individuals per year. These values will likely change, as estimates of available habitat are refined and restoration activities modify the area's carrying capacity.

For the purposes of this document, a *self-sustaining population* is defined as one that can sustain a specified population level without augmentation with captive-bred fish. A *managed population* is one that requires some augmentation to sustain specified population number.

Threats-based Criteria:

Recovery Objective 2-B. Habitat sufficient to support three such populations, as defined by criteria related to river base flow, hydrographs, and habitat and water quality (Factors A, C, D, and E).

Recovery Criterion 2-B-1. Base flow within occupied habitat sufficient to generate survival rates necessary to achieve Criteria 2-A-1. Wetted habitat represents the overall carrying capacity of a particular area for Rio Grande silvery minnow and influences survival rates for the population. The amount and distribution of base flows necessary for recovery can be informed by a PVA.

Recovery Criterion 2-B-2. Recruitment flows that generate population growth rates necessary to achieve Criteria 2-A-1.

Recovery Criterion 2-B-3. Habitat of sufficient quantity and quality to generate recruitment and survival rates that meet Criteria 2-A-1. Quantity and quality will vary by site but each location is likely to need increased nursery habitat and overall channel complexity. These increases can be achieved through restoration, flow management, and removing impediments to river migration, such as giant cane in the Big Bend area.

Recovery Criterion 2-B-4. Improve water quality within occupied areas and reintroduction sites to support recruitment and survival rates necessary to achieve Criteria 2-A-1.

Recovery Goal 3. Recover the Rio Grande silvery minnow to an extent sufficient to remove it from the List of Endangered and Threatened Wildlife (delisting).

Demographic Criteria:

Recovery Objective 3-A. Three self-sustaining populations within the Rio Grande silvery minnow's historical range, as defined by criteria related to population size, distribution and extinction risk.

Recovery Criterion 3-A-1. Three populations of Rio Grande silvery minnow, in the historical range of the species, each of which demonstrate (using quantitative analysis) a probability of extinction in the wild of less than 10% within 100 years.

Threats-based Criteria:

Recovery Objective 3-B. Habitat sufficient to support three such populations, as defined by criteria related to river base flow, hydrographs, and habitat and water quality (Factors A, C, D, and E).

Recovery Criterion 3-B-1. Base flows within occupied habitat sufficient to generate survival rates necessary to achieve Criteria 3-A-1.

Recovery Criterion 3-B-2. Recruitment flows that generate population growth rates necessary to achieve Criteria 3-A-1.

Recovery Criterion 3-B-3. Habitat of sufficient quantity and quality to generate recruitment and survival rates that meet Criteria 3-A-1.

Recovery Criterion 3-B-4. Water quality within occupied areas and reintroduction sites to support survival rates of Rio Grande silvery minnow necessary to achieve Criteria 3-A-1.

Actions Needed

Recovery actions in this plan are grouped into five categories:

1. Develop a thorough knowledge of the Rio Grande silvery minnow's life history, ecology, and behavior, and the current status of its habitat.
2. Restore, protect, and alter habitats as necessary to alleviate threats to the Rio Grande silvery minnow.
3. Ensure the survival of the Rio Grande silvery minnow in its current habitat and reestablish the species in suitable habitats within its historical range.
4. Implement and maintain an adaptive management program so that appropriate research and management activities are implemented in a timely manner to achieve recovery of the Rio Grande silvery minnow.
5. Design and implement a public awareness and education program.

Estimated Cost of Recovery

Costs associated with recovery are estimated for each of the five categories listed above, based on the years in which specific actions are scheduled to occur. These costs are furthered detailed in the section 6.0 Implementation Schedule and Costs. Total cost to recover the Rio Grande silvery minnow is estimated at $167,500,000.

Date of Recovery

If recovery actions are promptly and successfully implemented, and recovery criteria are met, reclassification to threatened could be initiated in 25 years. Delisting could be accomplished within 5 years of reclassification.

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1.0 BACKGROUND

1.1 Introduction

The Endangered Species Act of 1973 (ESA) as amended (16 U.S.C. 1531 et seq.) establishes policies and procedures for identifying, listing, and protecting species of wildlife that are endangered or threatened with extinction. The ESA defines an "endangered species" as "any species which is in danger of extinction throughout all or a significant portion of its range." A "threatened species" is defined as "any species which is likely to become an endangered species within the foreseeable future throughout all or a significant portion of its range." The decision to list a species is based on a consideration of the five factors listed in section 4(a)(1) of the ESA:

- Listing Factor A. The present or threatened destruction, modification, or curtailment of its habitat or range.
- Listing Factor B. Overutilization for commercial, recreational, scientific, or educational purposes.
- Listing Factor C. Disease or predation.
- Listing Factor D. The inadequacy of existing regulatory mechanisms.
- Listing Factor E. Other natural or manmade factors affecting its continued existence.

The Rio Grande silvery minnow (*Hybognathus amarus*) was declared an endangered species in 1994 (59 FR 36988) and added to the List of Endangered and Threatened Wildlife. The U.S. Secretary of the Interior is responsible for administering the ESA's provisions as they apply to this species. Day-to-day management authority has been delegated to the U.S. Fish and Wildlife Service (Service), an agency within the Department of the Interior.

To help identify and guide species' recovery needs, section 4(f) of the ESA directs the Secretary of the Interior to develop and implement recovery plans for listed species or populations. Such plans are to include: 1) a description of management actions necessary to conserve the species or population; 2) objective, measurable criteria that, when met, will allow the species or population to be removed from the List of Endangered and Threatened Wildlife; and 3) estimates of the time and funding needed to achieve the plan's goals and intermediate steps. Recovery plans are advisory documents. Recovery recommendations contained in such plans are aimed at lessening or alleviating the threats to the species and ensuring self-sustaining populations in the wild.

Procedures for reclassifying and delisting species are set forth in the ESA (section 4) and in the regulations (50 CFR Part 424) promulgated to implement its listing provisions. A species can be delisted if the Secretary of the Interior determines that it no longer meets the endangered or threatened status, based on a consideration of the five listing factors. Further, a species may be delisted, according to 50 CFR Part 424.11(d), if the best scientific and commercial data available substantiate that the species or population is neither endangered nor threatened, due to: 1) extinction; 2) recovery; or 3) a finding that the original data for classification of the species were in error.

A recovery plan for Rio Grande silvery minnow was first developed in 1999 (U.S. Fish and Wildlife Service 1999). This plan is a revision of the 1999 document. It includes new information based on recent research and an updated recovery program. Additionally, the plan now includes objective, measurable criteria for downlisting (to threatened) and delisting.

This section of the Rio Grande Silvery Minnow Recovery Plan (1.0) provides background information on the species, including its taxonomy, life history, and current distribution and population status. It also details the reasons (per the five listing factors) the species was listed as endangered, and describes the critical habitat that has been designated for the species and conservation efforts to date. Also included in section 1.0 is a detailed report on endangered species recovery actions from the tribal perspective, with recommendations on how Indian tribes and the Federal government can better cooperate on recovery issues; the report was prepared by the recovery team's tribal subgroup. Section 2.0 provides the overall recovery strategy for the Rio Grande silvery minnow. Section 3.0 describes the goals of the plan (prevention of extinction, downlisting, and eventual delisting), as well as the specific objectives that must be achieved to meet those goals and the criteria by which it will be determined if the objectives have been met. Section 4.0 outlines the management actions that will lead to the goals, objectives, and criteria being met, and recovery of the species. Section 5.0 details how the various components of the recovery plan (the criteria and the actions) address the threats that led to the species' endangered status. Section 6.0 outlines the implementation schedule for management actions, responsible parties and potential partners, and estimated costs. Additionally, information on historical Rio Grande silvery minnow population numbers and extirpations, as well as various documents that structure the government's relationship with Indian tribes, are included as appendices.

1.2 Status of the Species

The Rio Grande silvery minnow is one of seven species in the genus *Hybognathus* found in the United States (Pflieger 1980). Rio Grande silvery minnow is known to occur only in one reach of the Rio Grande River (sometimes referred to as Rio Grande or middle Rio Grande) in New Mexico, a 280 km (174 mi) stretch of river that runs from Cochiti Dam to the headwaters of Elephant Butte Reservoir (Bestgen and Platania 1991, Dudley et al. 2005). This includes a small portion of the lower Jemez River, a tributary to the Rio Grande north of Albuquerque. Its current habitat is limited to about seven percent of its former range, and is split by three river-wide dams into four discrete reaches (Figure 1). In December 2008, silvery minnows were introduced into the Rio Grande near Big Bend, Texas as a nonessential, experimental population under section 10(j) of the ESA (73 FR 74357) (Figure 2). Preliminary monitoring is being conducted to determine whether or not that reintroduction has been successful.

Throughout much of its historic range, the decline of the Rio Grande silvery minnow may be attributed in part to destruction and modification of its habitat due to dewatering and diversion of water, water impoundment, and modification of the river (channelization). Competition and predation by introduced non-native species, water quality degradation, and other factors may also have contributed to its decline.

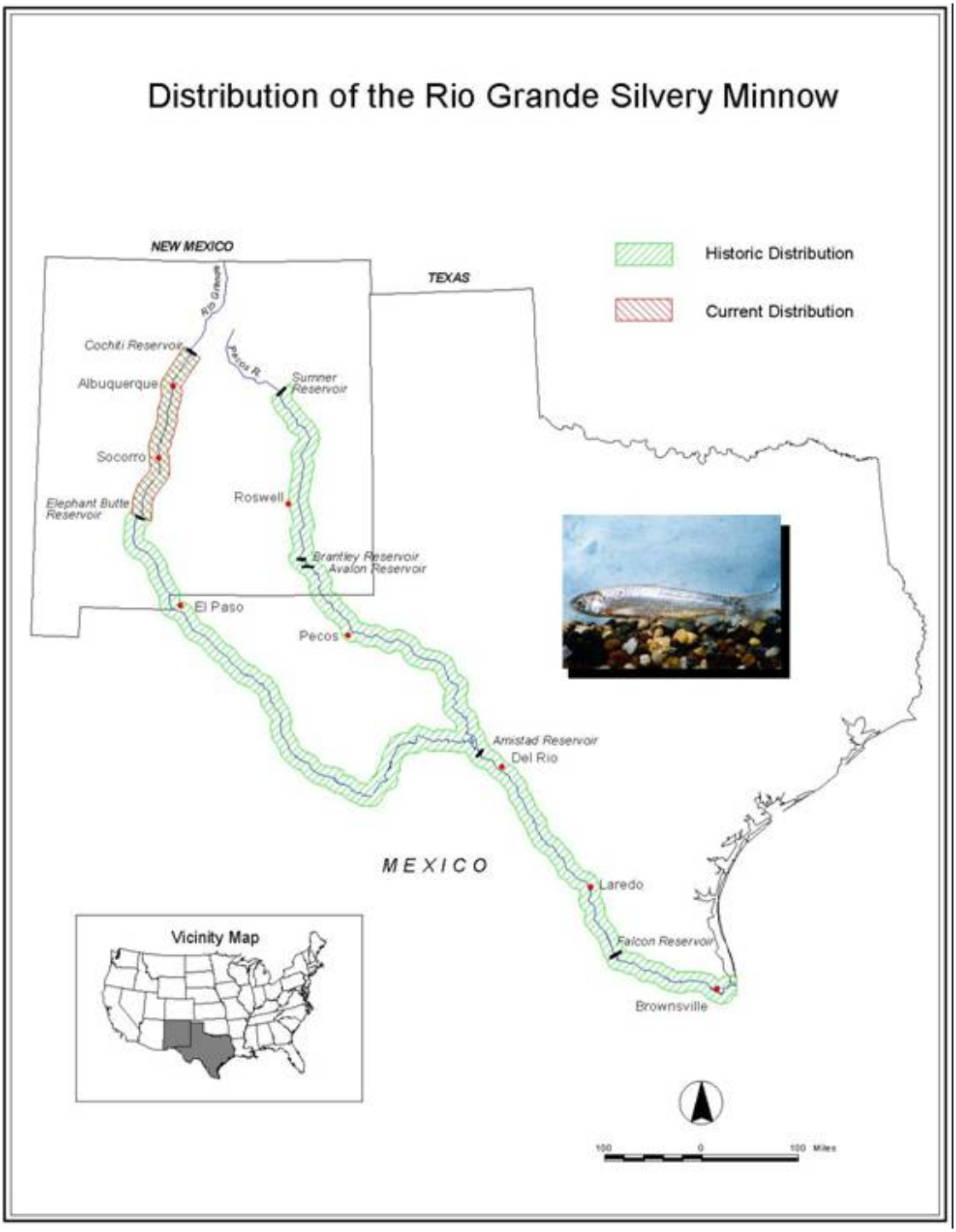

Figure 1. Historical and current distribution of Rio Grande silvery minnow.

The area currently occupied by the Rio Grande silvery minnow is roughly equivalent to the portion of the Rio Grande that is commonly known as the "middle Rio Grande." For the purposes of this document, the middle Rio Grande is defined as the stretch of river between Cochiti Dam and Elephant Butte Reservoir.

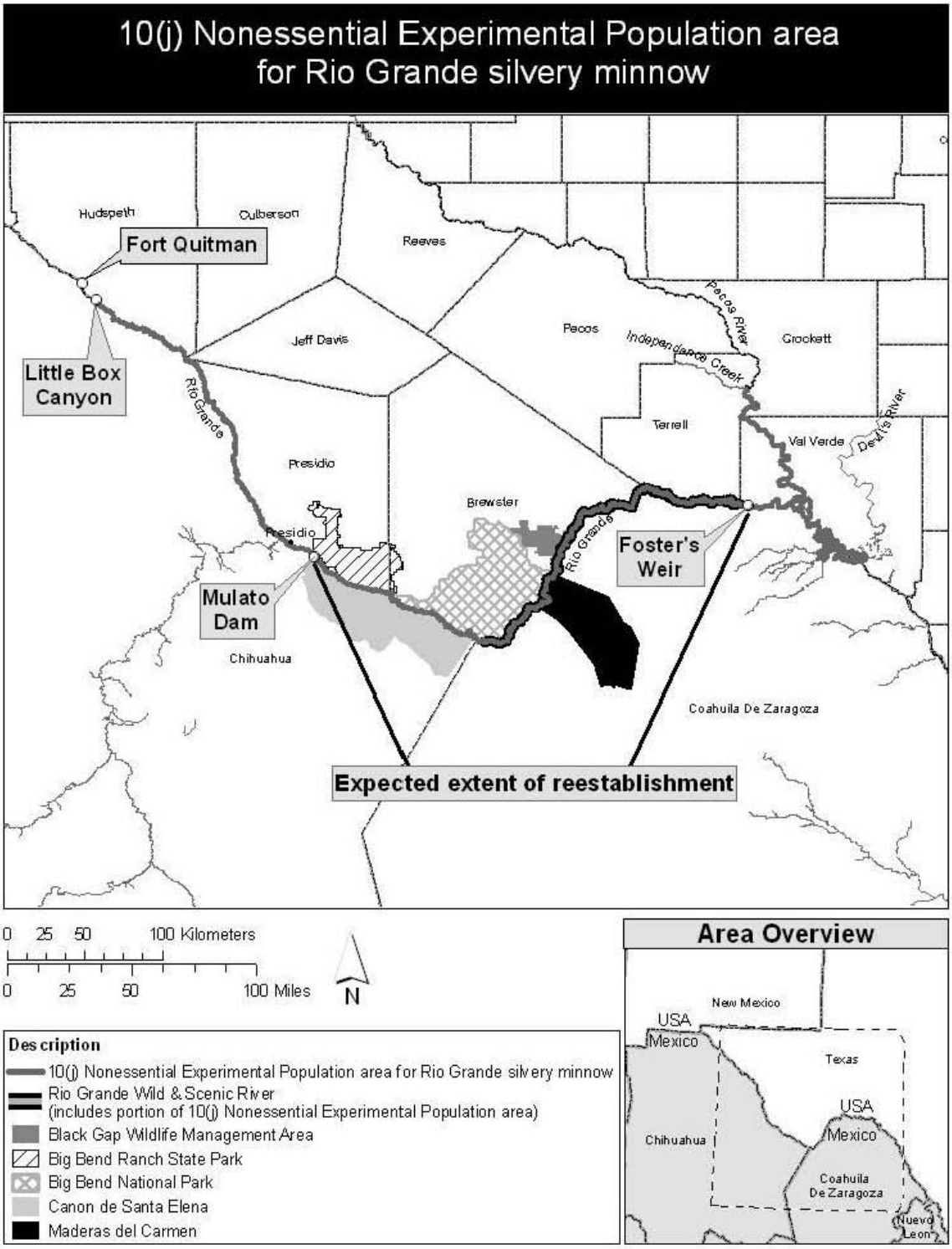

Figure 2. The 10(j) nonessential, experimental population area for the Rio Grande silvery minnow.

In addition to being federally-listed under the ESA in 1994, the Rio Grande silvery minnow was listed as endangered by New Mexico (19 NMAC 33.1), Texas (sections 65.171 - 65.184 of Title 31 T.A.C.), and the Republic of Mexico (SDS 1994).

While some of the threats mentioned above have been reduced since the Rio Grande silvery minnow was listed as endangered, none have been eliminated. The status of the species continued to decline through 2003. Since then, the relative abundance of Rio Grande silvery minnow in the remaining population (in the middle Rio Grande) increased demonstrating the highly variable nature of the population. Nonetheless, this population is fragmented and isolated, making it vulnerable to natural and human-caused factors further increasing the risk of extinction.

Each listed species receives a recovery priority number. The species recovery priority number for the Rio Grande silvery minnow is 2c, which is given for species with a high degree of threat, a high potential for recovery, and a number of existing conflicts between the species' recovery and economic development.

Critical habitat for the species was designated by the Service in 2003 (68 FR 8088). Designated critical habitat encompasses 252 km (157 mi) of the middle Rio Grande, from the Cochiti Dam downstream to the utility line at River Mile 62.1, just north of Elephant Butte Reservoir. The width of the critical habitat is defined as the area bound by existing levees, or where no levees are present, as 91.4 meters (300 ft) of riparian zone adjacent to each side of the bankfull stage of the middle Rio Grande. The Pueblo lands of Santo Domingo, Santa Ana (including lands within the Jemez watershed), Sandia, and Isleta found within this area are excluded from this designation because specific management plans for the Rio Grande silvery minnow were developed for these Pueblos prior to critical habitat designation (68 FR 8088).

1.3 Description and Taxonomy

The Rio Grande silvery minnow is a small, relatively heavy-bodied minnow, round to ovate in cross-section, with moderately small eyes and a small, slightly oblique mouth (Pfleiger 1980). Adults may reach 3.5 inches (89 mm) in standard length (SL)[1]). Live specimens are light greenish-yellow dorsally and light cream to white ventrally. Fins are moderate in length and variable in shape; dorsal and pectoral fins are rounded at tips. Scales above the lateral line are sometimes outlined by melanin-containing cells or melanophores, suggesting a diamond grid pattern. The head and snout are moderately pigmented dorsally by melanophores. The body is fully scaled, with breast scales slightly embedded and smaller. The subterminal mouth extends horizontally to almost the anterior margin of the orbit. The snout is rounded and overhangs the upper lip when viewed ventrally. The eye is small and orbit diameter is much less than gape width or snout length (Bestgen and Propst 1996) (Figure 3).

[1] Standard length, or SL, is measured from the tip of the snout to the base of the tail whereas total length or TL, is measured from the tip of the snout to the end of the tail

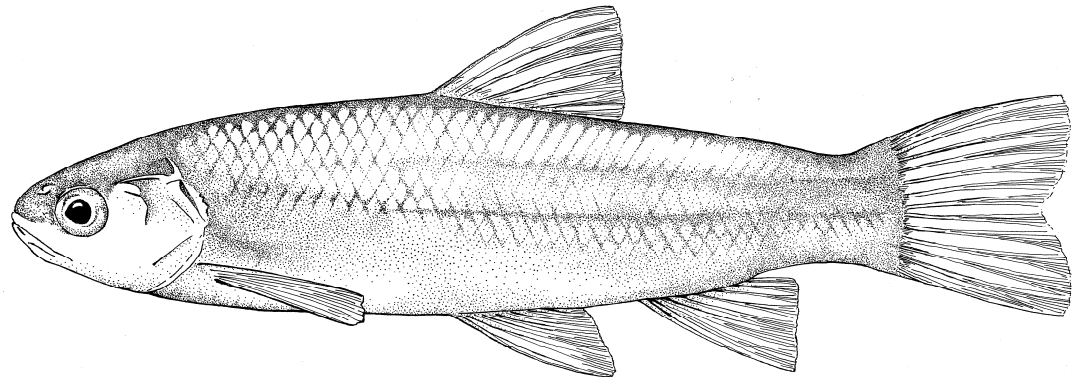

Figure 3. Rio Grande silvery minnow (U.S. Fish and Wildlife Service).

The species expresses little sexual dimorphism, i.e. the male and female look alike. The pectoral fins of males flare broadly from their base to a triangular fan shape; those of females are shorter, narrower, and oval-shaped. The pectoral rays of breeding males are thickened, while those of females are slender. Pectoral fin length is significantly greater for males.

The Rio Grande silvery minnow is a member of the broadly distributed genus *Hybognathus* (family *Cyprinidae*). Members of this genus are morphologically similar, which contributed to a confusing taxonomic history (Bestgen and Propst 1996). The species was originally described as *Algoma amara* by Girard (1856), based on specimens obtained from the Rio Grande near Brownsville, Texas. Over the next 120 years, it was variously synonymized with several other members of the genus. However, a detailed morphomeristic study, or study of physical characteristics, of *Hybognathus* by Bestgen and Propst (1996) demonstrated the distinctiveness of *H. amarus.* Additional details on the species' description and taxonomy can be found in the original listing package (59 FR 36988).

1.4 Life History/Ecology

Prior to Federal listing, little was known of the life history and ecology of the Rio Grande silvery minnow (Sublette et al. 1990). Much of the following information is derived from studies undertaken since the mid-1990s. All knowledge of Rio Grande silvery minnow life history and behavior is derived from studies in the middle Rio Grande which represents the remaining seven percent of the range, where substantial habitat loss and degradation has occurred.

1.4.1 Reproduction and Early Life History

The Rio Grande silvery minnow is a pelagic spawner (Platania 1995b) that produces thousands of semibuoyant, non-adhesive eggs that passively drift while developing (Platania and Altenbach 1998). This reproductive behavior and egg physiology is relatively common among fish species inhabiting the Rio Grande and the Pecos River, including four taxa that have been eliminated from the middle Rio Grande (Platania and Altenbach 1998).

Each female may produce 3 to 18 clutches of eggs in a 12-hour period. Mean clutch size is about 270 eggs. Eggs are about 1.6 mm (0.06 in) in diameter upon fertilization, but quickly swell to 3.0 mm (0.12 in). Following fertilization, the eggs drift with the current for up to 50 hours, remaining suspended in the water column during development (Platania 1995b). Egg hatching time is temperature dependent but rapid, and generally occurs in 24-48 hours (Platania 2000). More rapid development and hatching of eggs is observed in higher water temperatures.

In pelagic spawning, riverine fish such as the Rio Grande silvery minnow, the development of the gas bladder, absorption of the yolk-sac, and exogenous feeding (nutritional intake from outside the organism) generally indicate the transition from the passively drifting larvae to free-swimming larvae (Platania and Altenbach 1998). Approximately four days post-spawning at 25° C, the gas bladder of Rio Grande silvery minnow larvae develops, the fish begin exogenous feeding, and free-swimming is initiated (Dudley and Platania 2007). However, at colder temperatures, time to reach free-swimming was observed at approximately 7 days post-spawning at 20° C and 10 days post-spawning at 15° C (Dudley and Platania 2007). Recently hatched, passively drifting larval fish remain a part of the drift by swimming vertically in the water column. Free-swimming larvae are capable of swimming horizontally and appear to actively seek low velocity habitats (Platania and Altenbach 1998). Larvae are about 3.7 mm (0.15 in) total length (total length, or TL, is measured from the tip of the snout to the end of the tail) upon hatching. In low velocity habitats, growth is rapid and lengths of 39-41 mm (1.53-1.61 in) are attained by late autumn.

Spawning by Rio Grande silvery minnow is associated with high and/or increased flow events such as spring runoff or summer rainstorms, and typically occurs over a relatively brief period (1 month) in May or June, although spawning can occur later or earlier in the season when temperature and flows are suitable. Spawning takes place in the water column when water temperature is 18-24° C (64-75° F) (Platania and Dudley 2006).

From 1999 to 2008, peak spawning was observed to occur each year soon after the initiation of spring snowmelt runoff or the release of elevated flows from Cochiti Reservoir. With the exception of 2005, spawning observations from 1999 to 2007 appeared to be strongly associated with changes in flow and water temperature and each year the peak spawning period occurred over a very short time, typically a three-day period (Platania and Dudley 2008). Whether a rapid change in flow or overall flow magnitude initiates spawning in this species is unknown. Silvery minnow have been observed spawning after small increases in flow associated with localized summer storms (Remshardt, pers. comm.). Reproductive monitoring did not occur for Rio Grande silvery minnow in 2005 and it remains unknown whether there was a peak spawning period (2-3 days) or if it was extended (several weeks) due to high flows, but 2005 produced and supported substantially more Rio Grande silvery minnow than in the previous five years (Dudley et al. 2006).

Stresses associated with spawning appear to result in high mortality of Rio Grande silvery minnow. Typically, beginning in July and August, the observation of large individuals is greatly reduced and replaced by Age-0 individuals (Platania 1993b; Dudley and Platania 2007; Remshardt 2007, 2008). In general, by December, the majority of surviving Rio Grande silvery minnow is Age-0 fish – those that hatched the previous spring (Dudley and Platania 2007,

Remshardt 2007, 2008). Age-0 fish are defined as those that hatched in spring through December 31 (with January 1 as their nominal birthday, becoming Age-1) (Figure 3).

1.4.2 Length Frequency and Age

From Rio Grande silvery minnow length-frequency data collected from 2002 through 2006, there appears to be a minimum of two age classes at any one time, generally representing Age-0 and Age-1 between June and December and Age-1 and Age-2 between January and June (Remshardt 2007, 2008). Based on estimated length groups for assigning an age class, it is possible that some individuals are Age-3, although estimated Age-2 and Age-3 individuals appear to comprise a very small proportion of the total population in any given year (<5%). Despite these data, general agreement about maximum silvery minnow age and age-length relationships is lacking. Cowley et al. (2006) used scale annuli, growth ring on fish scales, to age silvery minnow collected in the 1870s (N=13) and concluded that the species may live up to five years in the wild. However, determining annuli from scales can be unreliable in small bodied fish, particularly as they age (Campana 2001). Furthermore, it is unknown whether extrapolation of age-length relationships from 1874 to the present would be valid, given significant changes in river conditions over the last 200 years. Most growth occurs between June (post-spawning) and October with variation in growth rates observed between years and reaches. Maximum size attained by wild Rio Grande silvery minnow is approximately 89 mm SL (3.5 in; Remshardt 2007). Maximum documented longevity in the wild is about 30 months for wild fish inferred from length-frequency, but up to 36 months for hatchery-released. It is not uncommon for Rio Grande silvery minnow in captivity to live beyond two years, especially at lower water temperatures. The U.S. Geological Survey's (USGS) Columbia Environmental Research Center in Yankton South Dakota has several silvery minnows in captivity with a maximum age of 11 that range in size from 46 to 73 (± 8.1) mm SL (Buhl, pers. comm.).

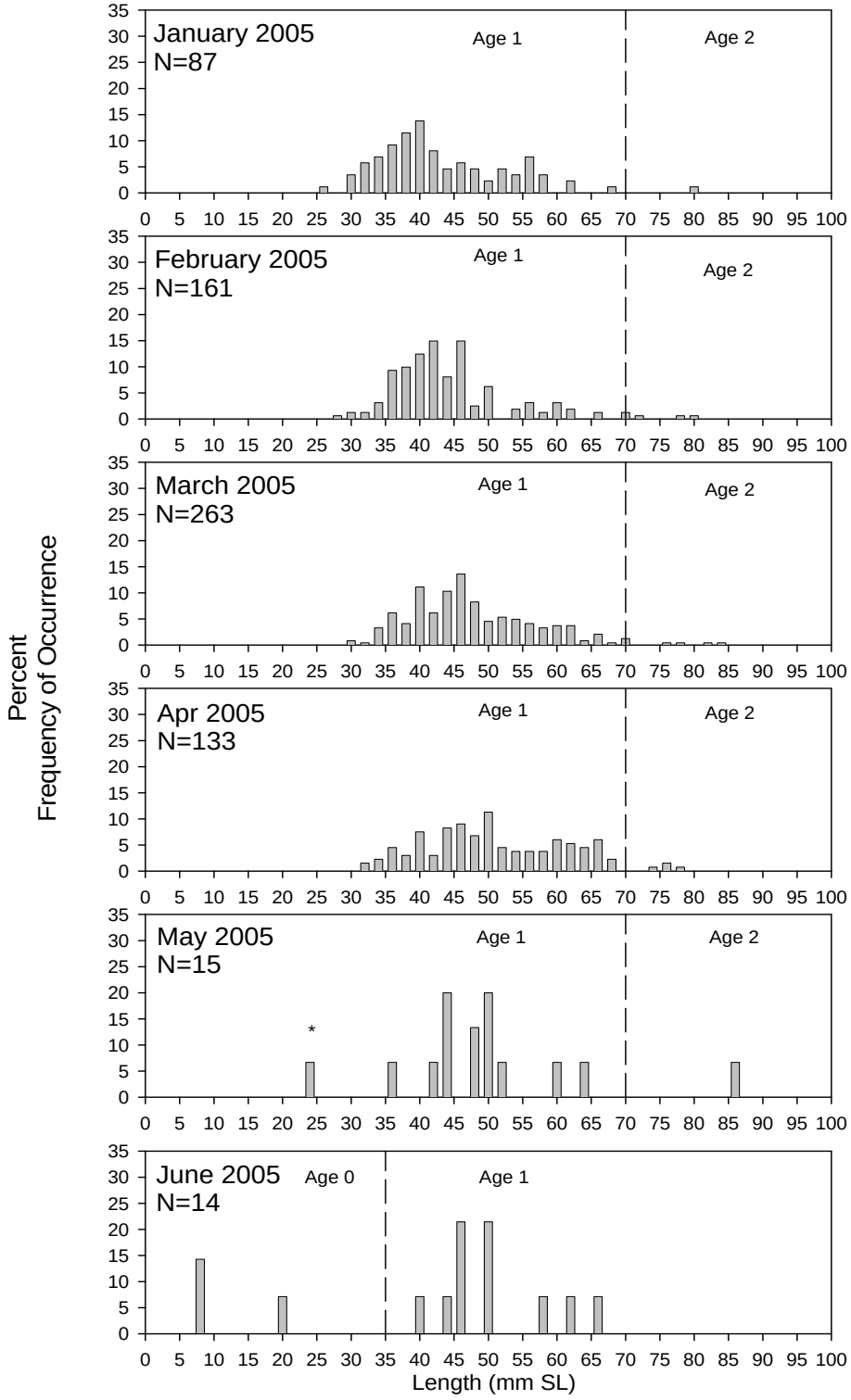

Figure 3. Length-frequency histograms of unmarked Rio Grande silvery minnow captured between January and June 2005. Dashed lines represent estimated breaks between year classes (Remshardt 2007).

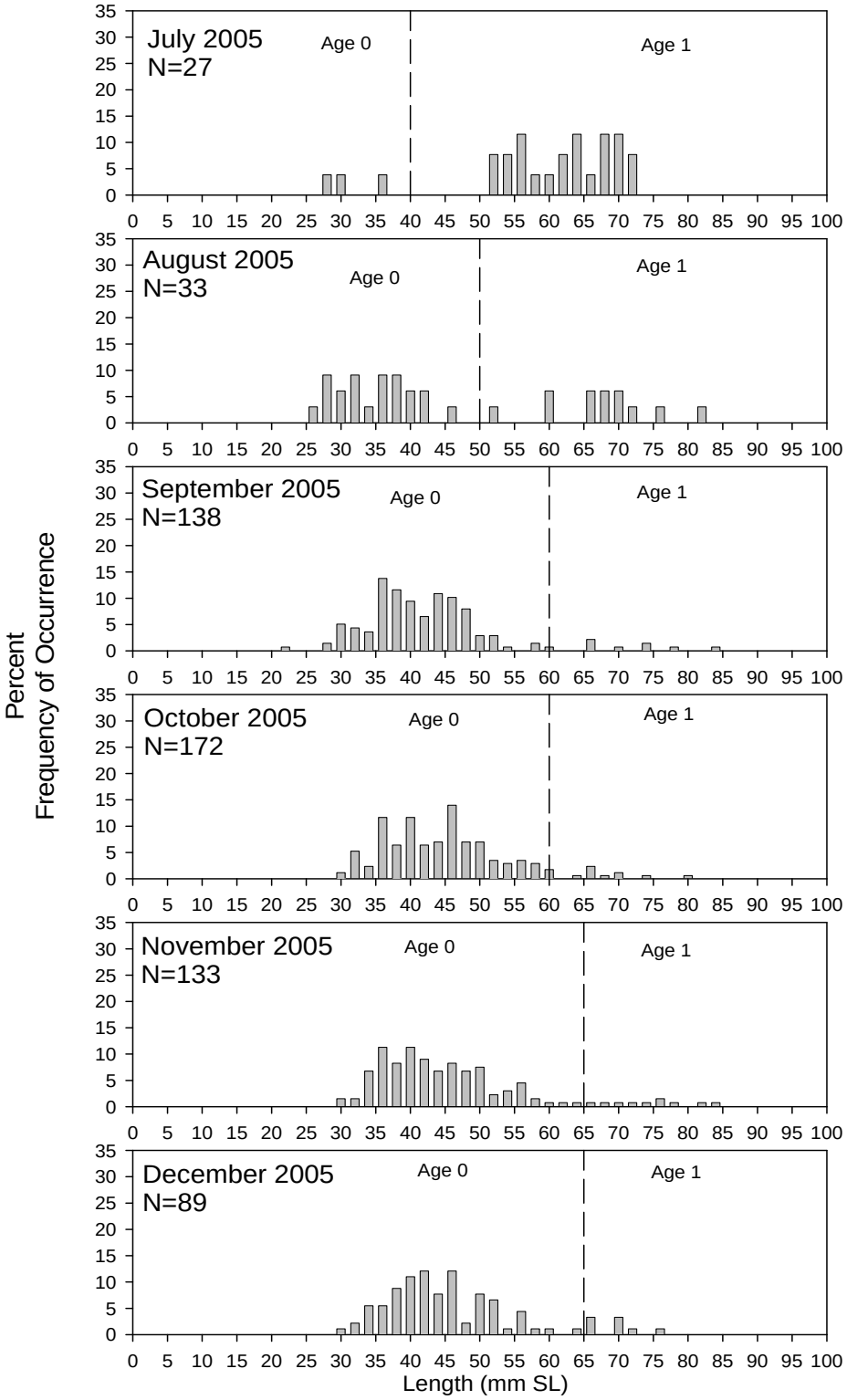

Figure 4. Length-frequency histograms of unmarked Rio Grande silvery minnow captured between July and December 2005. Dashed lines represent estimated breaks between year classes (Remshardt 2007).

1.4.3 Habitat Use

The middle Rio Grande valley has an arid to semi-arid climate typical of the southwestern United States. The area is characterized by abundant sunshine, low relative humidity, little precipitation, and wide diurnal temperature fluctuations. The Rio Grande itself, prior to widespread human influence was a wide, perennially flowing, aggrading river with a shifting sand substrate. The river freely migrated across a wide floodplain and was limited only by valley terraces and bedrock outcroppings. Detailed descriptions of the geography and climate of the Rio Grande and Pecos River can be found in Appendices A and B of the 1999 Rio Grande Silvery Minnow Recovery Plan (U.S. Fish and Wildlife Service 1999).

Studies in the Rio Grande have shown that Rio Grande silvery minnow use only a small portion of the available aquatic habitat (Platania 1993a, 1993b, 1997). In general, the species is most often found in areas of low or moderate water velocity (e.g., eddies formed by debris piles, pools, backwaters, and embayments) and is rarely found in habitats with high water velocities, such as main channel runs, which are often deep and swift (Dudley and Platania 1997, Watts et al. 2002, Remshardt 2007).

Habitat use data collected during Rio Grande silvery minnow augmentation monitoring throughout the middle Rio Grande (Remshardt 2007, 2008) reflected similar findings to other studies. No distinctions in habitat associations were observed between marked (hatchery) and unmarked (wild) Rio Grande silvery minnow. Rio Grande silvery minnow collections were positively associated with habitats that included low velocity and/or features that provide habitat diversity such as shorelines, debris, eddies, and submerged vegetation. The results from Remshardt (2008) are summarized in Figures 5 and 6.

1.4.4 Habitat Use by Life Stage

Passively drifting eggs and larvae are found throughout all habitat types. During the free-swimming stage, Rio Grande silvery minnow larvae almost without exception use relatively shallow areas with low or no water velocity and a fine particulate substrate (silt or silt/sand mixture) (Pease et al. 2006, Dudley and Platania 1997). Such conditions are most frequently encountered in habitats not directly associated with the main river channel (e.g., backwaters and secondary channel pools).

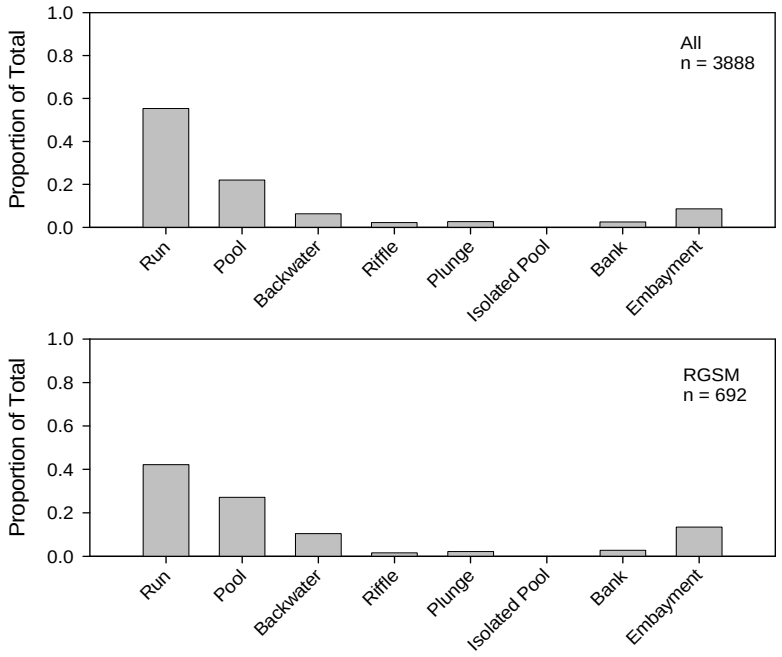

Figure 5. Mesohabitat types associated with all samples (top) and Rio Grande silvery minnow (RGSM) samples (bottom).

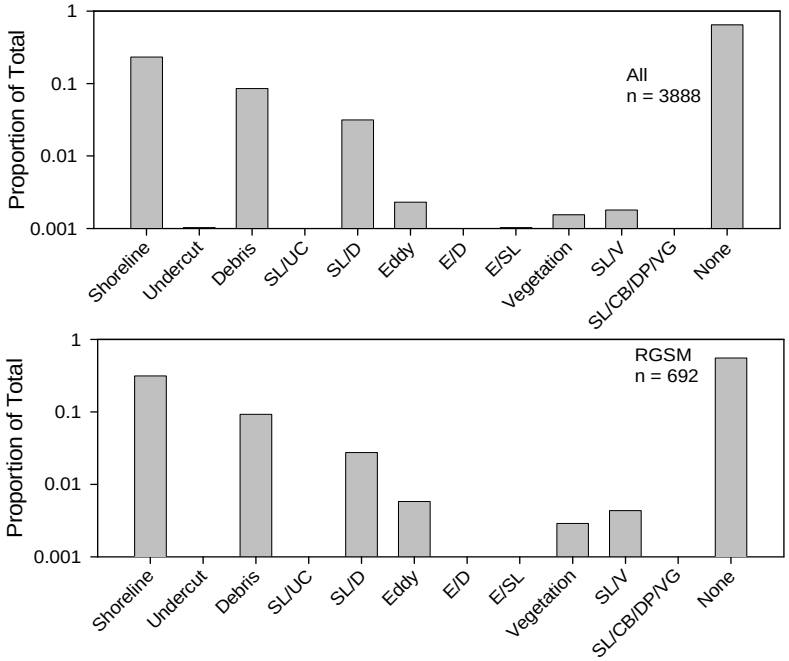

Figure 6. Features associated with all samples (top) and Rio Grande silvery minnow (RGSM; bottom) samples. Abbreviations for combinations of features are shoreline (SL), Undercut (UC), Debris (D), Eddy (E), and Vegetation (V).

Dudley and Platania (2007) reported that transport rates of early life stages were dependent on channel incision and width. Transport rates were highest in reaches immediately downstream of dams where channel narrowing and incision were most pronounced and slower in wider and less incised channel reaches, which allowed for more time for eggs and larval fish to develop to a free-swimming stage and move into nursery habitats (Dudley and Platania 2007).

As they grow larger, Rio Grande silvery minnows demonstrate an overall expansion in habitat use from low velocity areas to also include moderate-velocity areas. Low velocity habitats where small individuals are generally found, include backwaters, pools, and along shoreline habitats. While larger individuals can use a broader spectrum of habitats, such as main and side channel runs, the majority of all size-classes predominantly occupy low velocity habitats. Figure 7 from Remshardt (2008) depicts substrate associated with all samples and Rio Grande silvery minnow associations for comparison.

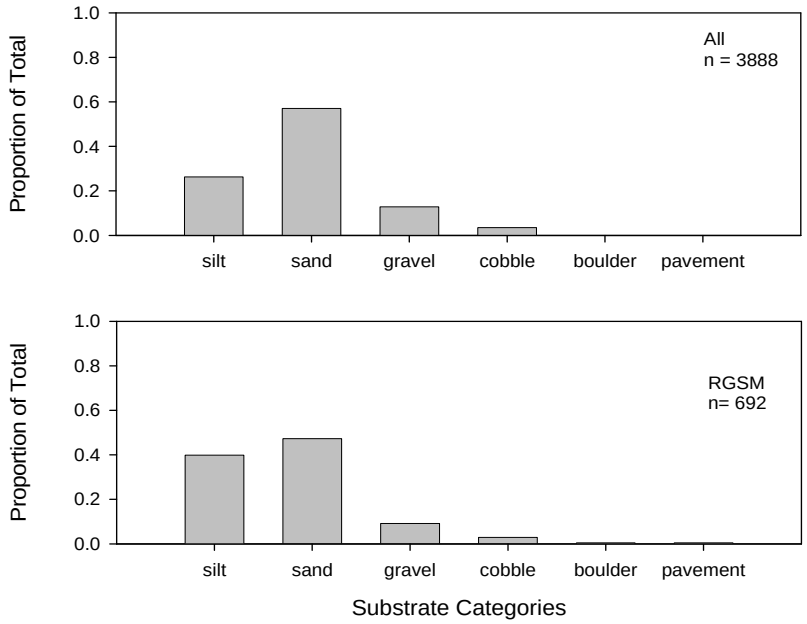

Figure 7. Percent of total substrate observations in all samples and in samples with Rio Grande silvery minnow between January 2006 and December 2006.

1.4.5 Seasonal Habitat Use

Habitat use differs from summer (April-September) to winter (October-March). Summer habitats include pools and backwaters. In winter, preferred habitat is found near instream debris piles; at that time, more than 70 percent of specimens are found in or adjacent to debris piles (Dudley and Platania 1996). Diminished water velocity appears to be a major factor influencing winter habitat selection.

The species also shifts to deeper waters in winter. Median depth shifted from 11-20 cm (4.33-7.87 in) in summer to 31-40 cm (12.2-15.75 in) in winter (Dudley and Platania 1997). Deeper areas generally have lower water velocities. Rio Grande silvery minnow are primarily found

over silt and sand substrate year-round, the dominant substrate types within the Rio Grande. Seasonal changes in substrate use have not been observed.

1.4.6 Diet and Food Availability

The Rio Grande silvery minnow has an elongated and coiled gastrointestinal tract, which is typical of an herbivorous fish. The presence of sand and silt in the gut of wild-captured specimens suggests that epipsammic algae (algae growing on the surface of sand) is an important food. Laboratory-reared Rio Grande silvery minnow have been directly observed grazing on algae in aquaria (Platania 1995b and Magana 2007).

Valdez et al. (in review) surveyed macroinvertebrate and aufwuch (a plant or animal organism which is attached or clings to surfaces of leaves or stems of rooted plants above the bottom stratum) diversity in the middle Rio Grande and found that they vary with mesohabitat features: shallow, low velocity habitats provide increased food availability for the Rio Grande silvery minnow. Drift macroinverterbrates were also strongly associated with season with higher abundances in May/June than in August, October, or December. Bixby and Burdett (2009) evaluated algal communities in the middle Rio Grande and found that their distribution is highly influenced by variation in turbidity and nutrients. In the summer months, high turbidity from tributaries creates a light-limited environment where primary production is limited to a littoral zone "bathtub ring." Additionally, there is a gradient of nutrient inputs as the river flows through urban landscapes as concentrations of phosphate and nitrates vary (Bixby and Burdett 2009).

1.4.7 Movement

The ecological aspects of Rio Grande silvery minnow movement are not fully understood. Movement studies in the wild have, to date, relied on hatchery fish which may not behave identically to wild individuals. A 2001-2002 mark-recapture study of wild-egg, hatchery-reared Rio Grande silvery minnow examined dispersal of Rio Grande silvery minnows (Platania et al. 2003). Collectively, 77 percent of marked fish released in January 2002 were collected within 48 hours either at or downstream of the release site. The distance traveled by these recaptured fish ranged from 1.1 km (0.68 mi) to more than 25 km (15.5 mi). Of the remaining fish, 11 Rio Grande silvery minnow were recaptured during or after April 2002, and 10 of these had moved upstream.

In 2006, the Service's New Mexico Fish and Wildlife Conservation Office conducted an evaluation of experimental stocking success of Rio Grande silvery minnow reared in captive propagation facilities and released throughout the current range in fall and spring (Remshardt 2008a). The recapture data from this effort provided additional information on movement of hatchery-produced and reared Rio Grande silvery minnow after their release. Recapture data indicated that movement was generally downstream following release and the majority of recaptures were within approximately 16 to 24 km (10 to 15 mi) downstream of the release site. Maximum distance traveled from release to recapture was 59.4 km (36.9 mi) downstream 300 days after release. Upstream movement was minimal, but some individuals were documented upstream from release locations, including one recapture 37.7 km (23.4 mi) upstream of the release site 256 days after release. The majority of recaptures occurred less than 100 days after release.

Bestgen et al. (2003) studied swimming performance of wild adult (55-88 mm SL) individuals in a lab setting and found that Rio Grande silvery minnow were capable of swimming rather remarkable distances in a relatively short time, especially given their small size. Between 15° and 23° C, they were routinely capable of swimming 50 km (31 mi) or more in about 48 hours, with one individual swimming the equivalent of 125 km (77 mi) in about 73 hours (Bestgen et al. 2003). It is noteworthy that this distance is more than any of individual reach length (Angostura, 65 km/40.4 mi; Isleta, 85.5 km/53.1 mi; San Acacia, 93.7 km/58.2 mi). Large concentrations of Rio Grande silvery minnow have been found immediately downstream of diversion dams in late summer and fall and suggest that movement is occurring at this time (Remshardt 2006). There could be several reasons for this movement including individuals moving upstream to escape intermittent sections of river and/or to offset downstream displacement.

1.5 Distribution and Population Trends

1.5.1 Overview

The Rio Grande silvery minnow was once one of the most widespread and abundant species in the Rio Grande basin of New Mexico, Texas, and Mexico (Bestgen and Platania 1991), occupying about 3,862 river km (2,400 mi). It was found in the Rio Grande from Española, New Mexico, down through New Mexico and Texas to the Gulf of Mexico (Bestgen and Platania 1991), and in the Pecos River from Santa Rosa, New Mexico, downstream to its confluence with the Rio Grande in Texas (Pflieger 1980). It was also found in the lower Rio Chama and the lower Jemez River, tributaries of the Rio Grande in New Mexico (Figure 1). It has never been found in any Mexican tributaries to the Rio Grande, despite extensive collection efforts (Edwards et al. 2003).

Today, the Rio Grande silvery minnow is no longer found in the vast majority (>93 %) of its historic range (Figure 1). It has been declining in distribution and abundance for more than 50 years, and has been extirpated from the Rio Chama and the Pecos River, as well as from most of its historic range in the Rio Grande. Information on the historical distribution of the species can be found in the 1999 Recovery Plan (U.S. Fish and Wildlife Service 1999).

The Rio Grande silvery minnow is the only remaining member of a reproductive guild of five cyprinids (all spawn eggs that are neutrally buoyant) that historically occupied the Rio Grande in New Mexico. The four other species in the guild have either been extirpated from the Rio Grande in New Mexico [speckled chub (*Macrhybopsis aestivalis*) and Rio Grande shiner (*Notropis jemezanus*)], or are extinct [phantom shiner (*Notropis orca*) and Rio Grande bluntnose shiner (*Notropis simus simus*)].

The currently occupied habitat of the Rio Grande silvery minnow is equivalent to only about seven percent of its former range, and is fragmented by dams (Angostura, Isleta, and San Acacia) into four discrete reaches: Cochiti Reach (35.9 km/22.3 mi), Angostura Reach (65 km/40.4 mi), Isleta Reach (85.5 km/53.1 mi), and San Acacia Reach (93.7 km/58.2 mi) (Figure 8). Sampling studies have documented the species in the three lower reaches (Angostura, Isleta, and San Acacia); the Rio Grande silvery minnow has not been documented in the Cochiti Reach since 1995 (Platania and Dudley 2003a, Torres et al. 2008). The currently occupied portion of the Rio Grande in New Mexico flows through several large municipalities, including the City of

Albuquerque and several large Native American Pueblos. The species was also recently found in the Lower Jemez River, between the Jemez Canyon Dam and its confluence with the Rio Grande (about 2.8 mi) (Pueblo of Santa Ana and USFWS 2004). A major portion (252 km/157 mi) of the species' current range was designated as critical habitat in 2003 (Figure 8).

In December 2008, Rio Grande silvery minnows were introduced into the Rio Grande near Big Bend, Texas as a nonessential, experimental population under section 10(j) of the ESA (73 FR 74357). Preliminary monitoring is being conducted to determine whether or not that reintroduction has been successful.

The remnant population of Rio Grande silvery minnow has undergone fluctuations in abundance which is highly correlated to hydrologic conditions (Dudley and Platania 2008). Rio Grande silvery minnow catch rates declined two to three orders of magnitude between 1993 and 2004, but then increased three to four orders of magnitude in 2005. Catch rates in recent years are similar to those observed at the time of listing (early 1990s).

1.5.2 Long-Term Monitoring

1.5.2.1 Long-term Monitoring Area and Methods

Long-term monitoring for the Rio Grande silvery minnow and fish communities in the middle Rio Grande began in 1993 and has continued annually, with the exception of 1998 and a majority of 2009. The area monitored for Rio Grande silvery minnow is the middle Rio Grande from Cochiti Dam to Elephant Butte Reservoir. However, most sampling occurs in the area from Angostura Diversion Dam to just above Elephant Butte Reservoir. The reaches in the section of river include Angostura Reach, Isleta Reach, and San Acacia Reach. The sampling methods are described in detail in Appendix E.

The Rio Grande silvery minnow and other fish species are monitored at selected sites. Currently, 20 sites are sampled monthly (5 in the Angostura Reach, 6 in the Isleta Reach, and 9 in the San Acacia Reach; Figure 9). With the exception of the Cochiti Reach, the same sampling sites have been used consistently since 1993, although several sites have been added over time to increase the spatial extent of sampling.

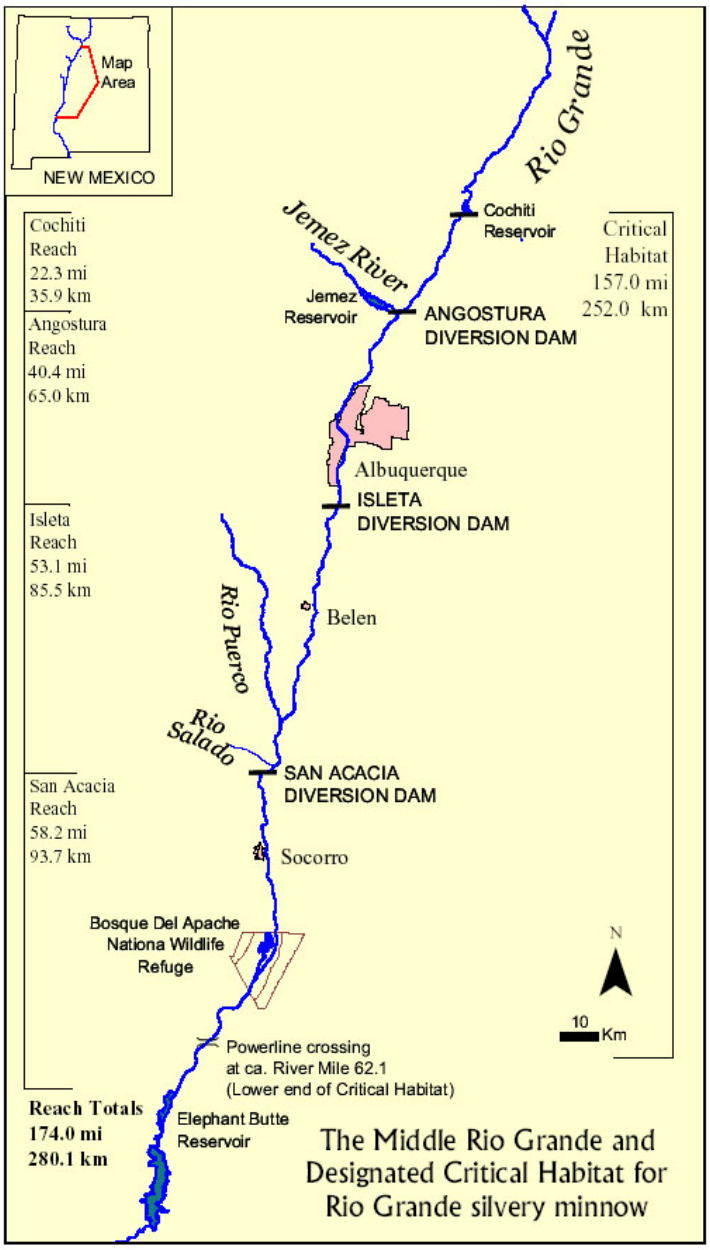

Figure 8. Rio Grande silvery minnow current habitat and designated critical habitat.

The Rio Grande shows considerable variety in hydrological and biological characteristics. At higher elevations upstream, it is a narrow coldwater river with large substrata and a salmonid-dominated fish community. Downstream areas are wide and sand-bottomed, and support a warm water fish community. Water flow is regulated by five mainstem reservoirs on the Rio Chama and Rio Grande and by numerous smaller irrigation diversion dams. The complex system of ditches, drains, and conveyance channels provide irrigation water for agriculture in the Rio Grande Valley.

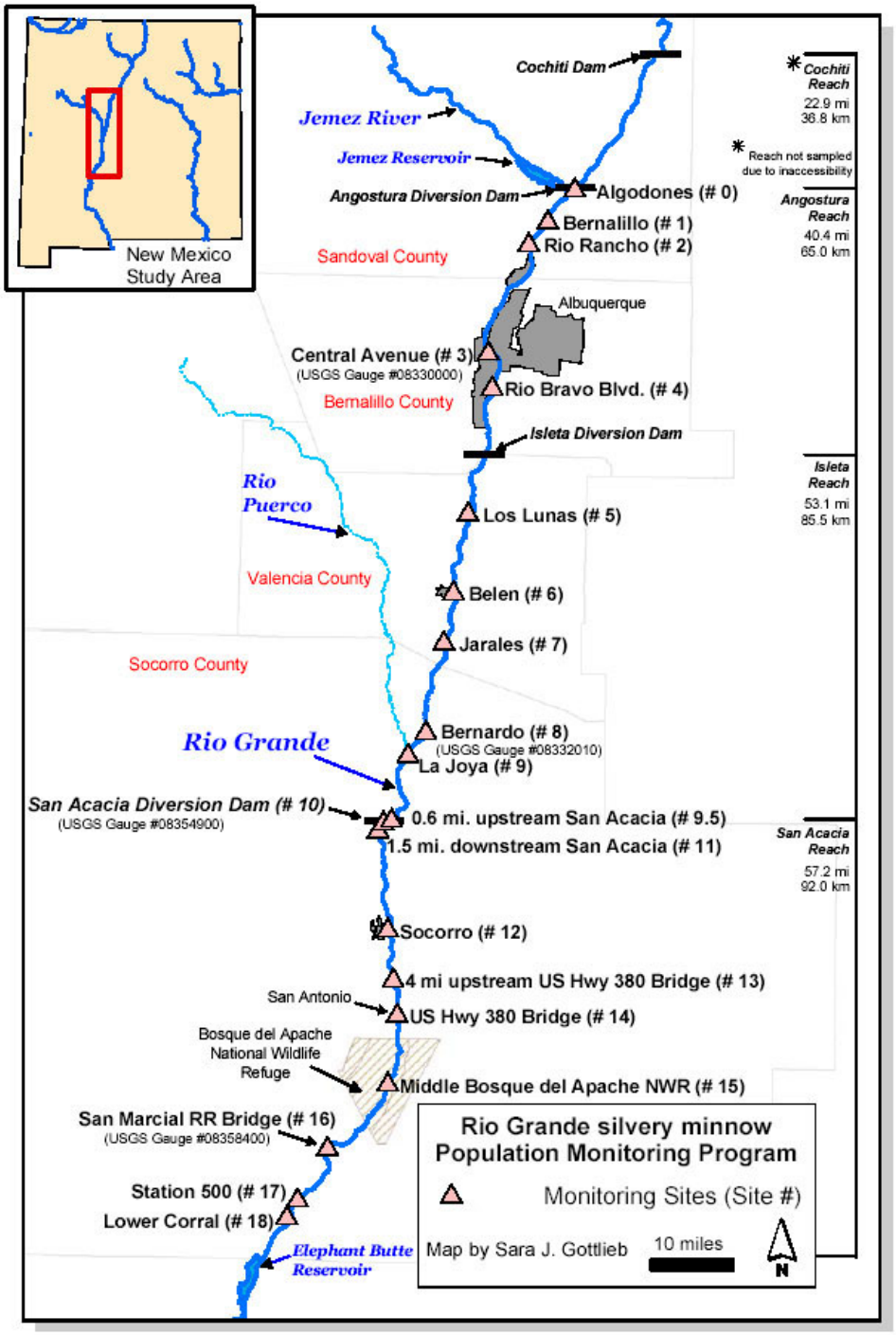

Figure 9. Rio Grande silvery minnow population study sampling locations.

The Cochiti Reach (35.9 km/22.3 mi), the uppermost portion of the study area, begins at Cochiti Dam. Here the river passes through the Pueblos of Cochiti, Santo Domingo, and San Felipe. Cochiti Reservoir, located 76 km (47.22 mi) upstream of Albuquerque and operational since 1973, is the primary flood control reservoir in the area and regulates flow to some degree in the

mainstem middle Rio Grande. Hypolimnetic water, the layer of water below the thermocline, released from the reservoir is cold and clear, creating a distinctly different riverine environment from the one that existed here historically. The river is highly incised in the Cochiti Reach because of flow regulation and the lack of an upstream sediment supply—upstream sediment settles out in Cochiti Reservoir (Harris 2007). The substrates in this reach are primarily cobble and gravel and there are few backwater or side channel habitats.

The Angostura Reach (65 km/40.4 mi) is downstream of the Cochiti Reach beginning at the Angostura Diversion Dam. It includes the portion of the river that passes through Albuquerque. The Isleta Reach (85.5 km/52.9 mi) begins a few miles south of Albuquerque, at the Isleta Diversion Dam. The San Acacia Reach, the farthest downstream reach in the study area, includes 93.7 km (58.2 mi) of the river, from the San Acacia Diversion Dam to Elephant Butte Reservoir.

The river changes considerably throughout the study area. The portion of the river between Angostura Diversion Dam to Bernalillo is a transition zone. The river channel becomes more braided, the floodplain widens, and the substrate is primarily gravel and sand. From Bernalillo downstream to Albuquerque, the channel often exceeds 100 meters (328 ft) in width, lower velocity habitats are more common, and sand and silt substrates become more dominant. Backwaters and side channel habitats are more abundant in this area than they are further north in the Cochiti Reach. Below Albuquerque, the Rio Grande is wide and braided with a predominantly sand substrate, high suspended silt load, and a wide variety of mesohabitats. The mainstem channel is generally wide (100-200 meters/328-656 ft) and less than 1 meter (3.28 ft) deep, with a velocity of less than 1 m/s. Further south, from about the middle of Bosque del Apache National Wildlife Refuge to the inflow of Elephant Butte Reservoir, the river channel is generally less than 50 meters (164 ft) wide.

Public access is intermittent in the Cochiti Reach, precluding long-term fish monitoring. The last comprehensive ichthyofaunal surveys of the Cochiti Reach documented the presence, at low abundance, of Rio Grande silvery minnow in that reach (Platania 1995a). However, a few other surveys since 1995 have not documented the presence of Rio Grande silvery minnow (Torres et al. 2008), and it is presumed that the species is no longer present in the reach or occurs in very low densities.

Annual catch rates, or catch per unit effort (CPUE), are assumed to provide a proportional index of population trends over time (Richards and Schnute 1986). October catch rates are used to determine trends. October flows are typically less variable than other months and young-of-year that have survived summer mortality may be considered "recruited" into the adult population.

The relationship between CPUE and abundance has received considerable attention in the literature (see reviews by Otis et al. 1978, Bannerot and Austin 1983). CPUE provides a metric to gauge spatial or temporal trends in populations and has been used by the USFWS to evaluate the silvery minnow's status in the middle Rio Grande since listing. Richards and Schnute (1986 and 1992) argue that CPUE is strictly proportional to population size. The probability of silvery minnow detection and of site occupancy varies across the different habitats utilized by the

species (Dudley et al. 2009). Habitat-specific correction values may be utilized to extrapolate total population size from CPUE.

1.5.2.2 Long-term Trends and Ecological Relationships: 1993 to 2008

The long-term monitoring of silvery minnows has recorded substantial (several orders of magnitude increases and decreases) fluctuations in the population. Rio Grande silvery minnow catch rates declined two to three orders of magnitude between 1993 and 2004, but then increased three to four orders of magnitude in 2005 (Figure 10). Population size is highly correlated with hydrologic conditions, particularly the magnitude and duration of the spring runoff (Dudley and Platania 2007). The capacity of the species to respond to good hydrologic years (e.g. 2005) is dependent on a variety of factors including the previous year's survivorship and number of adults available to reproduce.

Dudley and Platania (2008) reported on the significant relationships between Rio Grande silvery minnow catch rates and hydrologic variables (e.g. peak discharge, days greater than or less than a threshold value). At the Rio Grande at Albuquerque, New Mexico (Albuquerque) gage (http://waterdata.usgs.gov), October catch rates increased significantly with maximum spring discharge and all combinations of number of days with discharge exceeding a threshold value (Figure 11). The relationship that explained the most variation (91 percent) in mean October catch rate at the Rio Grande at Albuquerque gage was number of days with discharge greater than 3,000 cubic feet per second (cfs) during spring. At the Rio Grande Floodway at San Marcial, New Mexico (San Marcial) gage, the mean October catch rate increased significantly with maximum discharge and several of the combinations of number of days with discharge exceeding a threshold value (Figure 11). At the San Marcial gage, the relationships that explained the most variation (>90 percent) in the mean catch rate was number of days of discharge greater than 2,000 cfs as well as the number of days less than 200 cfs (negative relationship).

These relationships indicate that extended periods of low flow reduce habitat availability and may create unfavorable environmental conditions (e.g., high water temperatures, poor water quality) when flows approach very low levels in certain portions of the reach. In addition to high water temperatures and possibly poor water quality, the likelihood of interactions with the species and with other species (e.g., predator-prey or competition) would be expected to increase during low flows as available aquatic habitat decreases. Low flows also raise the likelihood of drying in portions of the reach, leading to loss of aquatic life.

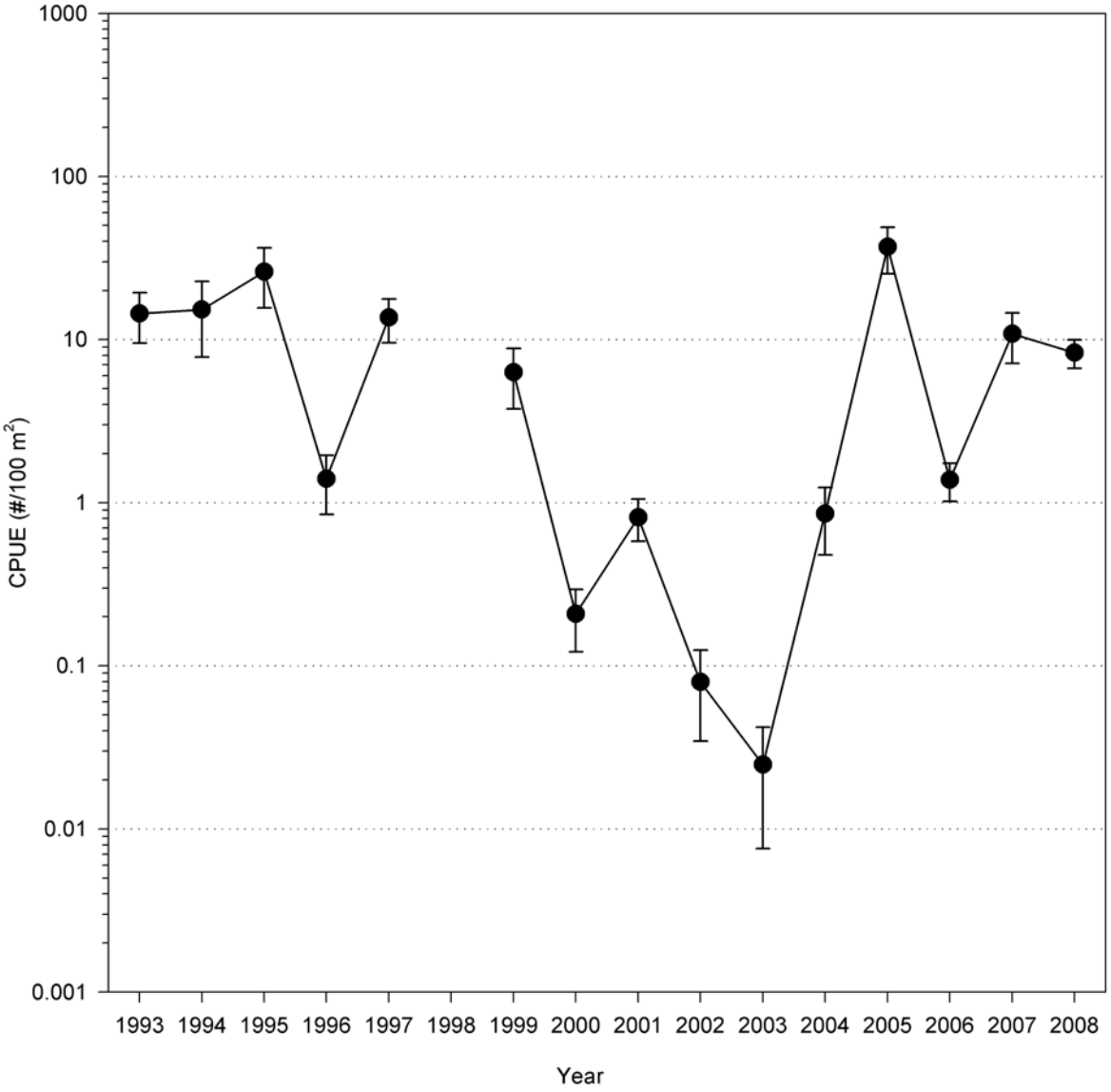

Figure 10. Rio Grande silvery minnow population trends 1993-2008 based on October CPUE data.

1.5.2.3 Rio Grande Silvery Minnow and the Total Fish Community

As part of the middle Rio Grande long-term monitoring project, Dudley and Platania (2007) have reported on the total fish community. Dudley and Platania (2008) have monitored the species of fish that are typically encountered in any given year in the middle Rio Grande (Table 1).

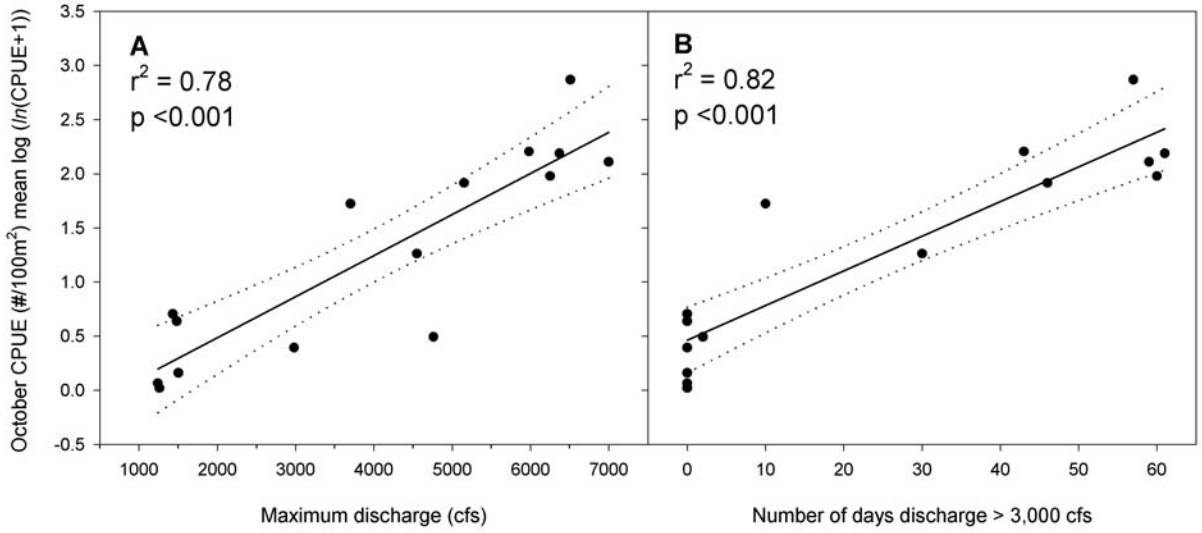

Figure 11. Relationship between CPUE and maximum discharge (cfs) and number of days that discharge exceeded 3,000 cfs at the Albuquerque gage (from Dudley and Platania 2008).

While the species present are typically consistent, the proportions of the species vary annually, primarily within the most abundant ten species (denoted by an asterisk in Table 1). Additionally, the fish community species proportions vary longitudinally between the three reaches of the middle Rio Grande (Dudley and Platania 2008).

Table 1. Scientific and common names and species codes of fish typically observed in the middle Rio Grande.

Scientific Name Common	Name (Code)
Order Clupeiformes	
Family Clupeidae herrings	
Dorosoma cepedianum	gizzard shad (GZS)
Family Cyprinidae carps and minnows	
Cyprinella lutrensis	red shiner * (RDS)
Cyprinus carpio	common carp * (CCA)
Hybognathus amarus	Rio Grande silvery minnow * (RGM)
Pimephales promelas	fathead minnow * (FHM)
Pimephales vigilax	bullhead minnow (BHM)
Platygobio gracilis	flathead chub * (FHC)
Rhinichthys cataractae	longnose dace * (LND)
Family Catostomidae suckers	
Carpiodes carpio	river carpsucker * (RCS)
Catostomus commersonii	white sucker * (WHS)
Ictiobus bubalus	smallmouth buffalo (SMB)
Order Siluriformes	
Family Ictaluridae North American catfishes	

Ameiurus melas .....black bullhead (BBH)
Ameiurus natalis ..... yellow bullhead (YBH)
Ictalurus furcatus..... blue catfish (BCT)
Ictalurus punctatus ..... channel catfish * (CCT)
Pylodictus olivaris ..... flathead catfish (FCT)

Order Salmoniformes
Family Salmonidae trouts and salmons
Salmo trutta .....brown trout (BNT)

Order Cyprinodontiformes
Family Poeciliidae livebearers
Gambusia affinis ..... western mosquitofish * (MOS)

Order Perciformes
Family Centrarchidae sunfishes
Lepomis cyanellus ..... green sunfish (GNS)
Lepomis macrochirus ..... bluegill (BGL)
Micropterus salmoides ..... largemouth bass (LMB)
Pomoxis annularis .....white crappie (WCR)
Family Percidae perches
Perca flavescens ..... yellow perch (YWP)
Sander vitreus ..... walleye (WLE)
Percina macrolepida.....log perch

* taxa that represent the 10 most abundant species present in recent middle Rio Grande collections.

The magnitude of change in catch rates of Rio Grande silvery minnow over time is particularly striking when compared to the overall fish catch rates (all species) of the past decade (Dudley and Platania 2007). For most fish species in the middle Rio Grande, rank abundance remained relatively constant over the past decade. In contrast, the percentage of the total fish community of Rio Grande silvery minnow is highly variable among years (Dudley and Platania 2007).

1.5.3 Rio Grande Silvery Minnow Population Estimate

Since 2006, the Middle Rio Grande Endangered Species Collaborative Program (MRGESCP) has funded studies to investigate methods for estimating population size for the Rio Grande silvery minnow (Dudley and Platania 2008). The objectives of these studies were to: 1) develop and implement methods that provide statistically robust population estimates of Rio Grande silvery minnow, 2) provide a population estimate of Rio Grande silvery minnow based on fish densities stratified by mesohabitat for 20 sampling units, 3) develop site occupancy rates for Rio Grande silvery minnow populations over time, and 4) calculate a population estimate of Rio Grande silvery minnow using Population Monitoring Program data, controlling for mesohabitat.

This study was structured to provide an estimation of the population of Rio Grande silvery minnow based on data collected from 20 sampling units in the study area. To maintain an unbiased probability of sampling at localities that support differing densities of Rio Grande

silvery minnow, sampling units in this study were selected randomly using a spatially balanced statistical design. All habitats at each site were mapped. In the third year of the study, different sampling strategies (closed versus unclosed) were tested for capture efficiency and to determine site occupancy rates by habitat.

The 2008 estimate incorporated sampling efficiencies by habitat and is considered the most reliable estimate of the three years. In 2008, silvery minnow numbers were highest in the Isleta Reach (N = 1,027,489) and lowest in the San Acacia Reach (N = 404,864). The standard errors associated with population estimates for the three reaches were proportionally comparable for the Angostura and San Acacia reaches; standard error was notably higher in the Isleta Reach. The total population estimate for all reaches combined (N = 2,283,790) had a standard error [SE] of 740,860. The standard error is a measure of the deviation from the mean. Basically, the actual population estimate is somewhere between N = 1,542,929 (N minus SE) and N = 3,024,650 (N plus SE). The overall proportion of each age-class exhibited a similar pattern among the three reaches (i.e., populations were highest in the Isleta and Angostura reaches and lowest in the San Acacia Reach).

Population estimates were also generated using data from the Population Monitoring Program October 2008 sampling efforts. The population estimates for the study area varied among reaches with the highest numbers recorded in the San Acacia Reach (1,020,935) and the lowest numbers in the Angostura Reach (204,488). The overall population estimate using the Population Monitoring Program data (N = 2,066,354) had a standard error [SE] of 369,320.08. The overall population estimate ratio between the two data sets was 0.90 and there was no significant difference in the total population estimate between the two population estimation methods. While there were seemingly higher or lower estimates between the Population Monitoring and Population Estimate data sets (among reaches and ages), statistical analyses revealed no significant differences between reach-specific or age-specific estimates using the two methods.

1.6 Genetics

The ability of a species to persist over the long term is determined in part by the amount of genetic variation that is retained by a species. As a population declines, genetic variation is lost which can lead to reduced viability and reproductive capability (Falconer 1981, Ralls and Ballou 1983), affect a species' ability to adapt and respond to environmental changes, and ultimately heighten the risk of extinction (Frankham 1995, Higgins and Lynch 2001).

Genetic data collected for the Rio Grande silvery minnow includes information from 10 generations: 1 generation that preceded the precipitous decline that occurred in the last decade (1987), 3 generations that preceded the augmentation program (1999, 2000, 2001; Alò & Turner, 2005), and 6 generations that were supplemented with captively spawned and/or captively reared stocks (2002-2007; Turner et al. 2005, Turner and Osborne 2007).

Evaluations of these data indicate that overall, mitochondrial (mt) DNA diversity declined nearly 18 percent between 1987 and 2005. There have been two sharp declines in mt DNA diversity in the "wild" Rio Grande silvery minnow population. The first occurred in 1999, the second in

2001. These losses of diversity followed a sharp decline in abundance of Rio Grande silvery minnow between 1995 and 1997, and again between 1999 and 2000, as catch rates declined by an order of magnitude (Dudley et al. 2004). These declines in diversity coincided with extensive drying in the San Acacia Reach of the Rio Grande River. Mitochondrial DNA diversity has continued to decline between 2004 and 2007 (Turner and Osborne 2007).

Declines in heterozygosity were recorded for the Rio Grande silvery minnow from 1987 to 1999 and between 2000 and 2002. Heterozygosity increased between 2002 and 2005. Supplemental stocking with captively-reared minnows from wild-caught eggs between 2001 and 2003 may have temporarily alleviated loss of alleles and heterozygosity in the wild (Turner and Osborne 2004). Heterozygosity declined again in 2007 (Turner and Osborne 2007).

Microsatellite allelic diversity was lower in 1999, but increased from 2000 and has remained stable through 2006. Allelic diversity, however, declined slightly in 2007 (Turner and Osborne 2007). Although numerical abundance of the wild population continued to decline drastically after 2001, reaching extremely low levels in 2003, there was no substantial loss of allelic diversity over that time period. Supplementation of the wild population with captively-reared fish probably played a large role in preventing the loss of diversity during this time.

Stocks reared from wild-caught eggs consistently show higher levels of allelic diversity than do stocks produced by captive spawning (Osborne et al. 2006). In particular, these stocks are more likely to contain rare alleles that are present at low frequencies in the wild population. In 2004 and 2005, captive spawning was initiated with a particular focus on maximizing genetic diversity of captive stocks. These stocks were produced using paired matings and although fewer fish were used, higher levels of allelic diversity were seen and inbreeding coefficients were considerably lower when compared to previous captive spawning events.

Genetic studies also have demonstrated that the effective population size (N_e) for the Rio Grande silvery minnow is a fraction of the census size (Alò & Turner 2005) and have suggested a mechanism that drives the effective size to very low levels (Osborne et al. 2005; Turner et al. 2006). The effective population size (N_e) is defined as the number of adult individuals that successfully contribute genes to subsequent generations (Frankham 1995). In other words, effective population size (N_e) is a measure that allows predictions about the rate of loss of genetic variation in a population and is generally equivalent to the number of individuals that contribute genes to subsequent generations. In natural populations, N_e is less than the census population size, which is the actual number of individuals that can be counted (Frankham 1995). For the Rio Grande silvery minnow, the spawning strategy of releasing floating eggs can result in the downstream displacement of eggs, especially in years or locations where overbank opportunities are limited. The presence of diversion dams (Angostura, Isleta, and San Acacia Diversion Dams) prevents the recolonization of upstream habitats (Platania 1995b) and has reduced the species' effective population size (N_e) to critically low levels (Aló and Turner 2005, Osborne et al. 2005). Adults, eggs and larvae are also transported downstream to Elephant Butte Reservoir. It is believed that none of these fish survive because of poor habitat and predation from reservoir fishes (U.S. Fish and Wildlife Service 1999).

The N_e for Rio Grande silvery minnow is estimated to be approximately 100. This estimate was calculated from measured genetic changes (due to genetic drift) across nine generations. Although we do not know the direct impacts of small genetic effective size in the silvery minnow, the rate at which genetic diversity is lost is inversely proportional to effective population size. There is ample indication that populations and species that have limited diversity are at increased extinction risk. Lack of variation within a population may prevent selection from acting on the variation and hence reduces the potential for adaptation to changing environmental conditions.

In conservation genetics literature two values for N_e have been recommended to conserve neutral genetic variation (Frankel and Soule 1981) (N_e = 500), and to maintain the normal adaptive potential in important traits, such as size, that are determined by multiple genes (N_e of 5000) (Lande 1995). Estimates of genetic effective size for silvery minnow have consistently fallen well below the lower of these numbers, and the current effective size is not sufficient to rule out genetic consequences of small N_e for the species. A minimum target N_e of 500 and ideally a much larger effective size has been recommended for the Rio Grande silvery minnow. It should also be emphasized that because all individuals do not contribute offspring to subsequent generations, N_e is a fraction of the population's census size.

Estimates of the N_e for stocks that were reared from wild-caught eggs were consistently lower than for wild counterparts. This indicates that samples collected and reared in captivity do not accurately reflect the allele frequencies or allelic diversity seen in the wild population. Failure to address these causal mechanisms, namely the interaction of life-history and river fragmentation, will cause genetic diversity to decline rapidly despite augmentation efforts.

1.7 Reasons for Listing/Threats Assessment

1.7.1 Historical Perspective

Historically, the Rio Grande silvery minnow occurred in the Rio Grande River from near Española, New Mexico, to near the Gulf of Mexico, and in the Pecos River from near Santa Rosa, New Mexico, to its confluence with the Rio Grande River.

Prior to the large-scale influence of humans on the watershed, the ecosystem that supported the species was a highly dynamic fluvial system with channel dimension, planform and profile reflective of the natural basin hydrology, sediment regime, and site-specific geological and local controls. It is believed that a significant portion of the river was a wide, braided, sand-bedded system with an extensive active floodplain composed of numerous secondary channels, floodplain lakes and marshes, and woody debris.

The Rio Grande River has undergone considerable change in the last 150 years and is no longer the highly dynamic system it once was. Several large dams and irrigation diversions have been built on the river, and the entire system is now operated to reduce flood threats and to supply water for irrigation and municipal and industrial uses. In many areas, channel incision has reduced overbank flow onto the floodplain. Channels have been straightened and deepened, and aquatic plants and snags have been removed to lessen hydrologic resistance and reduce the

retention time of water and organic matter. These changes have reduced the surface area and physical complexity of the habitat, reduced refugial habitats, prevented upstream movement of fish, and altered species interactions. The quantity and type of sediment entering the river has also changed, due to changes in watershed conditions and retention behind dams. Alterations in the magnitude and variability of flow, plus extractions of water for consumptive uses, have resulted in river drying, have reduced the magnitude, frequency, and duration of peak-flow events, and have increased the magnitude, frequency, and duration of low-flow events.

The Pecos River has also been constrained and altered due to the construction of dams and water management measures, with similar effects on the ecosystem (U.S. Fish and Wildlife Service 1999).

1.7.2 Extirpations

Due to these and other factors, the Rio Grande silvery minnow has already been extirpated from several portions of its historic habitat.

- In the Rio Grande River downstream of Elephant Butte Reservoir and upstream of Cochiti Dam, New Mexico, extirpation is believed to be due to the effects of large dams and other diversions, as described above. Sublette et al. (1990) documented the former occurrence of the Rio Grande silvery minnow in the Rio Grande between Caballo Reservoir, New Mexico, and El Paso, Texas, where the river channel is often dry.
- Hubbs et al. (1977) documented the "inexplicable" absence of Rio Grande silvery minnow from a reach of the Rio Grande River between El Paso, Texas, and its confluence with the Pecos River, where Hubbs (1958) had earlier documented the species to occur. However, Chernoff et al. (1982) noted that the Rio Grande between El Paso and the mouth of the Rio Conchos is at times virtually dry.
- In the Rio Grande downstream of its confluence with the Pecos River, Treviño-Robinson (1959) documented the early 1950s "cosmopolitan" occurrence of Rio Grande silvery minnow, and also noted that for "the first time in recorded history" a portion of this reach (near the mouth) went dry in 1953. Although Treviño-Robinson (1959) could not document any "apparent undesirable or severe after effects" from the drought, Rio Grande silvery minnow have not been documented in this portion of the Rio Grande since the mid-1950s (in part, U.S. Fish and Wildlife Service 1999).
- In the most downstream stretch of the Rio Grande River, Edwards and Contreras-Balderas (1991) documented the absence of the silvery minnow below Falcon Dam, citing declining stream flows and deteriorating water quality as the environmental stressors suspected to be responsible.
- In the Pecos River, hybridization and/or competition with non-native congener species (a member of the same taxonomic genus) may have operated to displace the Rio Grande silvery minnow. Moyer et al. (2005) report tests that excluded hybridization between *H. placitus* (plains minnow) and Rio Grande silvery minnow as a primary factor in species replacement and suggest interspecific competition may have led to species replacement in the Pecos River. *Hybognathus placitus* (plains minnow) was apparently introduced in 1968, probably from the Canadian Drainage (Cowley 1979). Replacement was complete in less than one decade.

For a reach-by-reach analysis of the last known collections of Rio Grande silvery minnow, see Appendix F.

1.7.3 Current Status

Today, the Rio Grande silvery minnow is known to occur only in one part of the middle Rio Grande of New Mexico, a 280 km (174 mi) stretch of river that runs from Cochiti Dam to Elephant Butte Reservoir. This includes a small portion of the lower Jemez River, a tributary to the Rio Grande north of Albuquerque. Its currently occupied habitat is equivalent to about seven percent of its historic range. In December 2008, silvery minnows were introduced into the Rio Grande near Big Bend, Texas as a nonessential, experimental population under section 10(j) of the ESA (73 FR 74357) (Figure 2). Preliminary monitoring is being conducted to determine whether or not that reintroduction has been successful.

The Rio Grande silvery minnow has, at times during the last 20 years, been very abundant in certain portions of the middle Rio Grande River, indicating that environmental and habitat conditions were at times conducive to its survival.

However, four species that shared similar ecological attributes with Rio Grande silvery minnow – speckled chub (*Macrhybopsis aestivalis*), Rio Grande shiner (*Notropis jemezanus*), phantom shiner (*Notropis orca*), and bluntnose shiner (*Notropis simus*) – have already been extirpated from the middle Rio Grande. All were short-lived cyprinids with a common reproductive strategy and egg type.

When the Rio Grande silvery minnow was designated as endangered in 1994 (59 FR 36988), the Service concluded that it should be listed because of the extremely limited habitat it currently occupies and its declining abundance, and because it can be expected to become extinct in the foreseeable future because of the remaining threats to the species and its habitat. While population size has increased in recent years, and efforts have been made to reduce threats and reestablish the Rio Grande silvery minnow in the Big Bend area of Texas, the species remains endangered.

1.7.4 The Five Listing Factors

The 1994 listing package (59 FR 36988) described numerous threats to the Rio Grande silvery minnow, categorized in terms of the standard five listing factors; additional threats have since been identified. The five listing factors, along with the originally identified threats to the species related to each factor, are listed below. The following discussion describes each in more detail including the extent to which a factor may have been addressed or have been deemed insignificant since it was first identified. Additional threats identified since listing are also presented.

Listing Factor A. The present or threatened destruction, modification, or curtailment of its habitat or range.

<u>Dewatering and Diversion</u>

- Annual dewatering of a large percentage of the species' habitat
- Risk of two consecutive below-average flow years, which can affect short-lived species.

- Increase in non-native and exotic fish species
- Increase in contamination concentrations during low flows, which may exacerbate other stresses
- Entrainment of eggs and young-of-year in diversion structures
- Fragmented habitat

Water Impoundment

- Altered flow regimes
- Prevention of overbank flooding
- Trapped nutrients
- Altered sediment transport regimes
- Prolonged summer base flows
- Reduced food supply
- Altered preferred habitat
- Prevention of species' dispersal
- Creation of reservoirs and altered flow regimes that favor non-native fish species that may compete with or prey upon the species
- Stored spring runoff and summer inflow, which would normally cause flooding
- Reduced flows, which may limit the amount of preferred habitat and limit dispersal of the species
- Lack of suitable habitat for young-of-year
- Fragmented habitat

River Modification

- Confined flood flows
- Trapped sediment
- Establishment of stabilizing vegetation
- Elimination of meanders, oxbows, and other components of historic aquatic habitat
- Replacement of preferred sand and silt substrate with gravel and cobble
- Reduction of floodplain areas where young can develop
- Geomorphological changes to the river channel

Water Pollutants

- Poor water quality caused by agriculture and urbanization in the Rio Grande River basin, especially during low flows and storm events

Listing Factor B. Overutilization for commercial, recreational, scientific, or educational purposes.

- Possible over-utilization through scientific collecting
- Licensed commercial bait dealers possibly selling bait minnows
- Incidental utilization of species during legal collection of bait minnows for personal use

Listing Factor C. Disease or predation.

Disease

- Risk of stress and disease when Rio Grande silvery minnow are confined to pools during periods of low flow
- Increased risk of stress-induced disease outbreaks possibly exacerbated when high levels of pollutants or other stresses are present

Predation

- Predation by non-native fishes, as well as by birds and mammals
- Competition for space and food with non-native fish during low flows

Listing Factor D. The inadequacy of existing regulatory mechanisms.

- No protection of habitat under State law
- Inability to acquire instream water rights for the benefit of fish and wildlife
- Inadequate regulations to restrict the use of bait fish, illegal use of bait fish, introduction of non-natives via bait bucket, and introduction of disease or parasites by importation of bait fish

Listing Factor E. Other natural or manmade factors affecting its continued existence.

- Reduced population numbers and potential loss of genetic diversity
- Introduction and subsequent competition from non-native fish

1.7.5 Listing Factor A. The Present or Threatened Destruction, Modification, or Curtailment of Its Habitat or Range

Loss of habitat can occur with channel drying (as a result of meteorological drought conditions, extraction of water for consumptive uses, including from groundwater sources, and reservoir storage of water); water impoundment (such as that caused by large dams); channel straightening and other geomorphic channel alterations (which, for example, reduces surface area and physical complexity of the habitat, and reduces retention time of water and organic matter); and pollution. All of these factors are currently affecting the habitat of the Rio Grande silvery minnow and threatening the survival of the existing population.

1.7.5.1 Dewatering and Diversion

Dewatering (channel drying) is caused primarily by the diversion of water for agricultural and other uses and by climatic drought. This can affect the Rio Grande silvery minnow in several ways, including causing a loss of habitat or fragmented habitat.

During the more than 100 years for which flow records have been maintained, portions of the middle Rio Grande River between Angostura Diversion Dam and Elephant Butte Reservoir have experienced river drying. Drying in the early part of the twentieth century has been attributed to large-scale increases in land irrigation in Colorado (in 1896 San Luis Valley water commissioners reported a total on 213,210 acres of land were irrigated and in 1924 a total of 621,826 acres) and below Elephant Butte (Harris 2007). During drying periods in the early part of the twentieth century, it is suspected that Rio Grande silvery minnow survived in areas where irrigation return flows re-entered the river, in shorter reaches supported by groundwater or water leaking through the gates of the diversion dams, and in wet reaches of stream above the diversions (from which offspring could repopulate downstream reaches when conditions permitted).

The amount of water diverted at irrigation structures remains relatively constant from year to year, such that the relative percentage of water being diverted increases as the flow in the river decreases. During low-flow years, it is possible to completely divert all of the flow from the river channel into irrigation ditches, especially below Isleta and San Acacia diversion dams.

River reaches particularly susceptible to drying occur immediately downstream of the Isleta Diversion Dam (river mile 169), a 5-mile (8-km) reach near Tome (river miles 150-155), a 5-mile (8-km) reach near the U.S. Highway 60 Bridge (river miles 127-132), and an extended 36-mile (58-km) reach from near Brown's Arroyo (downstream of Socorro) to Elephant Butte Reservoir. Extensive fish kills, including tens of thousands of silvery minnows, have occurred in these lower reaches when the river has dried. It is assumed that mortalities during river intermittence are likely greater than documented levels, for example due to predation by birds in isolated pools (J. Smith, NMESFO, pers. comm. 2003). From 1996 to 2007, an average of 32 miles (18 %) of the Rio Grande has dried each year, mostly in the San Acacia Reach. The most extensive drying occurred in 2003 and 2004 when 60 (34%) and 68.7 (39%) miles, respectively, were dewatered. Most documented drying events lasted an average of two weeks before flows returned. In contrast, 2008 was a wet year, with above average runoff and at least an average monsoon season. As a result, there was no river intermittency for the first time since at least 1996.

Irrigation diversions and drains significantly reduce water volumes in the river. However, since 2001, improvements to physical and operational components of the irrigation system have contributed to a reduction in the total diversion of water from the middle Rio Grande by the Middle Rio Grande Conservation District (MRGCD). Prior to 2001, average diversions were 630,000 acre-feet per year (afy) and now average 370,000 afy. The change was possible because of new gages, automated gates at diversions, and the scheduling and rotation of diversions among water users. The new operations reduce the amount of water diverted.

The entrainment of Rio Grande silvery minnow (primarily eggs and larvae) in the infrastructure of irrigation systems is also suspected to contribute to the decline of the species (U.S. Fish and Wildlife Service 1999). Entrainment is the transport of eggs and larvae into irrigation systems resulting from the flow of river water into those structures. The species does not persist in the irrigation ditches, drains, or the Low Flow Conveyance Channel (LFCC; a low elevation channel in the San Acacia Reach constructed in the 1950s to convey Rio Grande Compact water during low flows). During the irrigation season, all life stages of native fish including Rio Grande silvery minnow can be entrained into irrigation and conveyance systems. Cowley et al. (2007) found that the incidence of native species in the Peralta canals (Isleta Reach) was higher during the irrigation season. The LFCC was not operated to any large scale between 1985 and 1996. Platania (1993a) collected fish samples from 11 locations along the LFCC from 1987-1989 and failed to locate any Rio Grande silvery minnows. During experimental operation of the LFCC from 1996-1998, catch rates of Rio Grande silvery minnow eggs and juveniles increased similar to that observed in the adjacent river, but by early 1999, catch rates decreased to pre-operation levels (Smith 2000).

The outfalls of irrigation and conveyance systems may provide some relief during low-flow periods, but the importance of these is unknown. Rio Grande silvery minnow have been reported at drain outfalls in constructed habitat features (Wesche 2009) and in outfalls within drying reaches such as observed in 2003-2004 (Cowley et al. 2007). These refuge habitats are generally small, discontinuous, and support non-native predators, but they do provide aquatic habitat during low-flow periods. Cowley et al. (2007) noted that fish assemblages in the Isleta Reach

were primarily influenced by direct downstream movements of fish from the upstream Albuquerque Reach following significant drying in 2002-2004, not from the irrigation system.

1.7.5.2 Water Impoundment

Impoundment of water in the Rio Grande by mainstem dams has affected the flow regime of the river, fragmented habitat, and resulted in geomorphological changes to the channel.

Since the completion of Elephant Butte Dam in 1916, one additional dam has been constructed in New Mexico on the mainstem of the Rio Grande (upstream of Elephant Butte) and five have been constructed on major tributaries. In addition, three river wide diversion structures have been built on the middle Rio Grande, replacing pre-existing individual rock and brush diversion structures. These structures and their associated reservoirs were built for various purposes, including: 1) to allow for irrigation diversion from the river (Angostura, Isleta, and San Acacia Dams), 2) flood control (El Vado, Cochiti, Jemez Canyon, Galisteo, and Abiquiu Reservoirs), 3) storage of Rio Grande water (El Vado Reservoir), and 4) storage of San Juan Chama Project water (Heron, El Vado, and Abiquiu Reservoirs). The construction and operation of these structures and their associated reservoirs have modified the natural flow of the river.

Flood control reservoirs store a portion of the spring runoff that, if not stored, could result in levee breaches and/or significant flooding of homes, businesses, and irrigated lands. Most of the stored flood water is released shortly after the peak snowmelt runoff. In isolated cases, after July 1 of a high runoff year, any flood water remaining in storage is held over until the end of the irrigation season and then released. Additionally, native Rio Grande water can be stored in El Vado Reservoir during the snowmelt runoff for later release to meet irrigation diversion demand. Finally, San Juan Chama Project water (water diverted into the Rio Grande River from the San Juan River basin) is stored in several reservoirs and released on call to meet various downstream demands. The ultimate effect of the reservoir operations is to reduce the size of the flood peaks, extend or decrease the duration of the snowmelt runoff (depending on the size of the runoff), and increase the volume of water entering the middle Rio Grande during normal natural low flow periods.

Such altered flow regimes depart significantly from natural conditions, and reduce or modify habitat by preventing overbank flooding, trapping nutrients, altering sediment transport regimes, prolonging summer base flows, and creating reservoirs that favor non-native fish species. These changes affect the Rio Grande silvery minnow by reducing its food supply, modifying its preferred habitat, preventing dispersal, and providing a continual supply of non-native fish that may compete with or prey upon the species. Altered flow regimes may also result in improved conditions for other native fish species that occupy the same habitat, causing those populations to expand at the expense of the Rio Grande silvery minnow.

Fragmentation of the habitat by the dam structures is considered to be a factor in the decline of the Rio Grande silvery minnow. Diversion dams do not preclude downstream passage of fish or their propagules (drifting eggs and larvae), but they do prevent upstream movement of fish. Upstream movement of individual fish in dam-free (>25 km/15.5 mi) areas has been seen in studies of marked hatchery-reared individuals (Platania et al. 2003). Reductions in the species'

effective population size (N_e) to critically low levels (Aló and Turner 2005, Osborne et al. 2005) has been attributed, in part, to fragmentation by diversion dams.

1.7.5.3 River Modification

Channelization of the middle Rio Grande has resulted primarily from the placement of Kellner jetty fields, or jacks, along the river. These are designed to protect levees by retarding flood flows, trapping sediment, and promoting the growth of vegetation. Since 1951, U.S. Bureau of Reclamation (BOR) and U.S. Army Corps of Engineers (COE) have installed more than 100,000 jacks, occupying more than 2,000 hectares (5,000 ac) (Bullard and Wells 1992).

The effects of such actions can be seen downstream. From Elephant Butte Dam downstream about 325 km (202 mi) to the Rio Grande's confluence with the Rio Conchos, the river is fully controlled by reservoir releases and irrigation return flows. Meanders, oxbows, and other components of the historic habitat have been eliminated in order to pass water as efficiently as possible for agricultural irrigation and downstream deliveries. The sandy substrate that the Rio Grande silvery minnow prefers has been replaced by gravel and cobble, and no backwater areas exist where the young can develop. Winter flows released from Caballo Dam often equal 0.06 cubic meters per second (two cubic feet per second), which is not enough flow to maintain habitat for fish.

The loss of low velocity habitat, the generally preferred habitat of the Rio Grande silvery minnow, is of particular concern. The species is collected from only a small portion of the available aquatic habitats (Dudley and Platania 1997), so the loss of an already limited amount of suitable habitat is especially problematic. Such losses may most severely affect the smaller size-classes of Rio Grande silvery minnow and other cyprinids, as low velocity nursery habitats are essential for the survival of larval and juvenile Rio Grande silvery minnow. The habitats used almost without exception by most young-of-year fishes, and especially the Rio Grande silvery minnow, are the relatively shallow areas of low or no water velocity over fine substrate. These conditions are most often encountered in backwaters and secondary channels pools, not the main channel.

The species also seeks out low velocity habitat in the winter, in particular instream debris piles. This is a critical survival factor, as in winter fish are relatively inactive and rarely feed, and lower velocity areas provide a place where the energy costs of maintaining position in the water column are greatly reduced. Elevated winter water releases can result in a decrease in low velocity habitats and often make areas with debris one of the few available and suitable habitats. Elevated winter releases can also mobilize instream debris and reduce its availability to fish.

1.7.5.4 Water Pollution

The growth of cities and agricultural operations along the Rio Grande River in New Mexico over the last century has adversely affected the river's water quality. During low-flow periods, a large percentage of the river's flow consists of municipal and agricultural discharge and less water is available to dilute pollutants. This degradation of water quality affects Rio Grande silvery minnow survival. Poor water quality in the Rio Grande near Albuquerque, especially during low flows, may be a particular problem, as low numbers of the species and an overall reduced fish community are typically found there (Bestgen and Platania 1991).

The U.S. Geological Survey's Yankton Ecotoxicology Research Center in Yankton, South Dakota, which retains a small number of silvery minnows from multiple age classes, has also conducted research with the species. Studies began in 1998, comparing relative sensitivity and acute toxicity of Rio Grande silvery minnow and a surrogate species (fathead minnow) to a variety of waterborne inorganic contaminants. The center is currently conducting toxicity testing with larval fish obtained from the City of Albuquerque's Biological Park (BioPark).

Water quality may also be a concern in the Rio Grande near Big Bend (Texas), where reintroduction is underway. The "Binational Study Regarding the Presence of Toxic Substances in the Rio Grand/Rio Bravo and its Tributaries Along the Boundary Portion Between the United States and Mexico" was initiated in 1992 by the International Boundary and Water Commission. In Phase 1, 19 mainstem and 26 tributary sites from El Paso to Brownsville, Texas, were assessed (chemical analysis of water, sediment, and fish tissue; toxicity tests on water and sediment; and benthic community indices) (International Boundary and Water Commission (IBWC) 1994, Texas Natural Resources Conservation Commission (TNRCC) 1994). The TNRCC found high-level water quality impairment due to pesticides and toxic chemicals in the Rio Grande River below International Dam and near its confluence with the Río Conchos, as well as in the Río Conchos. Elevated levels of bacteria, dissolved salts, and nutrients have also been found (IBWC 2003).

1.7.6 Listing Factor B. Overutilization for Commercial, Recreational, Scientific, or Educational Purposes

There is no evidence that the species is being overutilized for commercial, recreational, scientific, or educational purposes.

The Service and New Mexico Department of Game and Fish (NMDGF) manage all collections of this species in New Mexico through a permit process. Requests by individuals and institutions for permission to retain Rio Grande silvery minnow requires detailed justification by the applicant during the permit application phase of the process. As with all Federal fish and wildlife endangered species, those applications are carefully reviewed to determine the merits of the request, its relevance for the recovery of the species, and potential impacts to the population. The number of individuals that may be retained are reviewed annually in reference to the best available information on the species population levels. During the mid- and late 1990s, multi-agency biological studies were initiated requiring retention and sacrifice of Rio Grande silvery minnow (i.e., reproductive ecology, age and growth, life-history, laboratory spawning). Retention and sacrifice of Rio Grande silvery minnow since 2003 has been primarily limited to larval specimens (<15 mm TL) that could not be accurately identified under field conditions and eggs used in propagation efforts. The extremely small area within this species range that was sampled during early collecting events and limited number of specimens retained is unlikely to be of sufficient magnitude to adversely impact the population.

Licensed commercial bait dealers may sell bait minnows only within the drainage where they have been collected. They are also restricted from selling any State-listed fish species. However, it has been demonstrated on the Pecos River in New Mexico that the dealers and retailers often cannot identify listed fish species. Use of the species for recreational purposes

could occur should an individual unknowingly collect the species while gathering bait minnows for personal use.

There is no evidence to suggest overutilization of the Rio Grande silvery minnow for any of these purposes poses a substantial threat to the species.

1.7.7 Listing Factor C. Disease or Predation

1.7.7.1 Disease

During periods of low flow, fish confined to pools may experience stress that can result in outbreaks of parasitic disease. Most notable is parasitism by the protozoan *Ichthyophthirius multifilis.* External parasites, such as the copepod *Lernaea*, also are more common among fish in confined conditions. In addition, stress-induced outbreaks may be exacerbated when high levels of pollutants or other stresses are present.

The U.S. Fish and Wildlife Service conducted a Rio Grande silvery minnow health study from July 2006 to July 2008 (Year 1 and Year 2). Adult and juvenile Rio Grande silvery minnow were collected nearly every three months from six sites in the Rio Grande from Bernalillo to San Antonio, New Mexico. Additional measures of water quality (e.g., dissolved oxygen, temperature, pH, and conductivity) were also taken and the collection and chemical analyses of water and sediment were conducted contemporaneously at these or nearby sites by others (S. Stringer, New Mexico Environment Department, written communication, 2008). Examinations of viral, bacterial and parasite pathogens were conducted. Individual fish were also measured, weighed, and dissected to permit observation of the internal organs. Shortened opercules, gill pathologies, liver abnormalities, and degenerated kidney tubules were observed with the greatest frequency and most indicators occurred at a greater rate in Year 2 than in Year 1. The percent of fish with pathological lesions tended to increase from upstream to downstream. Generally, the health of the Rio Grande silvery minnow deteriorated from Year 1 to Year 2, from upstream to downstream, and during the summer (July). Additional site specific analyses are ongoing and the final report is expected in late 2009. At this time, the significance of these threats is not known.

1.7.7.2 Predation

Although it is unlikely that predation is a major factor in the decline of the Rio Grande silvery minnow, it has probably played a minor role, with increasing importance as populations have come under greater stress from other factors.

Non-native species, including northern pike (*Esox lucius*), walleye (*Stizostedion vitreum*), white crappie (*Pomoxis annularis*), white bass (*Morone chrysops*), black and brown bullheads (*Ameiurus melas*, *A. nebulosus*), channel catfish (*Ictalurus punctatus*), flathead catfish (*Pylodictus olivaris*), smallmouth bass (*Micropterus dolomieu*), and largemouth bass (*M. salmoides*), prey on the Rio Grande silvery minnow. Predation increases when these species are

confined, during low flow or no flow, in limited habitat with Rio Grande silvery minnow and other native species.

These non-native species were introduced primarily by State and Federal fish and wildlife management agencies in efforts to develop sport fisheries in the reservoirs created by mainstem dams. The introduced species have not remained confined to the reservoirs and have become established in the river both upstream and downstream, where it is suspected they may compete with Rio Grande silvery minnow for space and food, in addition to preying upon them.

Native predatory fish species, including the Rio Grande chub (*Gila pandora*), blue catfish (*Ictalurus furcatus*) and bluegill (*Lepomis macrochirus*), may also prey upon sub-adult Rio Grande silvery minnow under circumstances of limited habitat. In addition, most species of fish will prey on eggs and larval Rio Grande silvery minnow. Avian predation by herons and bitterns, for example (Family Ardeidae), may also increase when Rio Grande silvery minnow become confined in small clear-water pools.

The effects of such stressors on populations of Rio Grande silvery minnow are currently unquantified.

1.7.8 Listing Factor D. The Inadequacy of Existing Regulatory Mechanisms

1.7.8.1 No Protection of Rio Grande Silvery Minnow Habitat Under State Law

The State of New Mexico lists the Rio Grande silvery minnow as an endangered species, Group 2 (NMDGF 1988), which includes those species "whose prospects of survival or recruitment within the State are likely to be in jeopardy within the foreseeable future." This listing provides the protection of the New Mexico Wildlife Conservation Act (section 17-2-37 through 17-2-46 NMSA 1978) and prohibits taking of such species except under the issuance of a scientific collecting permit. However, the protection afforded to the species by the State does not extend to the habitat upon which the species depends.

1.7.8.2 Instream Water Rights for Fish and Wildlife

At the time the Rio Grande silvery minnow was listed as endangered, the interpretation in New Mexico was that State water law did not provide for "instream flow," (i.e., the acquisition and use of water rights for the instream protection of fish and wildlife and their habitats). However, since the listing, the New Mexico State Engineer and the New Mexico Attorney General have separately opined that no provision of State water law prohibits the State Engineer from issuing a permit for the use of water for "instream flow " purposes. State law does require that such a permit only be issued pursuant to an application for such a permit by a person or public entity (as defined in State law).

1.7.8.3 Inadequate Regulations to Restrict the Use of Bait Fish

State game and fish regulations in New Mexico once allowed the use of live minnows, including those brought into the State from other drainages, for sport fishing. While this is no longer allowed, the practice encouraged the spread of non-native species, one of which, the plains minnow, completely replaced and/or hybridized with Rio Grande silvery minnow in the Pecos River.

Cowley (1979) discovered the introduction of plains minnow (*H. placitus*) into the Pecos River drainage, New Mexico, from collections made as early as 1968, and also recognized the disappearance there of Rio Grande silvery minnow. The last known collections of Rio Grande silvery minnow from the Pecos River took place in 1968 near Roswell, New Mexico. These same collections verified the first specimens of *H. placitus* from the river. It is suspected, because of the widespread use of *H. placitus* as a commercial bait species, that its introduction was a result of the release of bait fish by anglers.

The use of live minnows from other drainages may also have introduced diseases and parasites harmful to Rio Grande silvery minnow.

While existing regulations preclude the legal introductions of non-native bait fish, it is possible that the illegal use of non-native bait fish continues. Such activities may introduce species that may compete with or prey upon Rio Grande silvery minnow or introduce diseases or parasites harmful to the species.

1.7.9 Listing Factor E. Other Natural or Manmade Factors Affecting its Continued Existence

1.7.9.1 Reduced Population Numbers and Potential Loss of Genetic Diversity

The current population of Rio Grande silvery minnow has been severely reduced from its historic size (see Section 1.6), making the species particularly vulnerable to problems that are intrinsic to small populations, including extinction due to population fluctuations, loss of genetic diversity, and threats from congener competition and hybridization.

Reductions in numbers and populations of Rio Grande silvery minnow increase the risk of decreased genetic diversity and the potential for inbreeding depression. This could lead to a reduced ability of the species to cope with environmental variability and to further reductions in overall population size and in recruitment and reproductive potential (Gilpin and Soulé 1986).

Reduced populations always risk decreased genetic viability. Genetic viability describes the pool of genetic diversity adequate to allow a population of animals to survive environmental pressures that may exceed the limits of plasticity. Genetic variability consists of within population genetic diversity and genetic variation found among linked populations or stocks.

One way to assess genetic risk is through consideration of "genetic effective population size" (N_e), which is roughly the number of individuals contributing genes to the next generation. Effective population size can be used to gauge the number of individuals needed in a population to maintain genetic variation and to determine the degree of genetic risk to wild populations. The N_e likely differs by species and specific genetic analyses are needed to determine the N_e for the Rio Grande silvery minnow. Studies (Alò & Turner 2005, Turner et al. 2003, Turner and Osborne 2004) to date indicate that the N_e for the remaining population of Rio Grande silvery minnow is around 100 individuals, despite recent population supplementation from hatchery-reared and captively-bred fish. Small populations in the wild risk inbreeding (interbreeding of

closely related individuals) which results in reduced fitness and ability to cope with random environmental fluctuations (stochasticity).

1.7.9.2 Competition with Non-Native Fish

As mentioned above, the State of New Mexico once allowed the use of live minnows, including those brought into the State from other drainages, for sport fishing. This practice encouraged the spread of non-native species, including the plains minnow, which replaced and/or hybridized with Rio Grande silvery minnow in the Pecos River. Such competition and/or hybridization with non-native species in the future could potentially affect the remaining populations of Rio Grande silvery minnow. The degree and extent of this threat is not fully understood.

1.7.9.3 Climate change

Ongoing and future changes in climate have the potential to adversely affect Rio Grande silvery minnow. Analyses of snowpack and snowmelt runoff trends suggest that 93% of New Mexico's watersheds have become increasingly drier since 1970 and that the timing of the runoff peak is an average of one week earlier than in the mid-20th century (Enquist et al. 2008). Temperature increases have already been observed in New Mexico and are predicted to continue (Watkins 2006). Milder winters and hotter summers, are likely to result in longer growing seasons and increased plant and human water use. At the same time hotter, drier conditions will increase evaporative losses from reservoirs, streamflows and soils. These conditions will reduce the amount of water available to maintain river flows and associated habitat for the Rio Grande silvery minnow. Additionally, changes in timing of spring runoff, may adversely affect spawning and recruitment, particularly if runoff occurs at a time when water temperatures are outside the optimal range.

1.8 Critical Habitat

1.8.1 Critical Habitat Description

Critical habitat for the Rio Grande silvery minnow was designated in 2003, under section 4(a)(3)(A) of the Endangered Species Act (68 FR 8088).

Critical habitat was designated for the species in New Mexico, only in the middle Rio Grande. Critical habitat extends from Cochiti Dam, in Sandoval County, downstream to the utility line that crosses the river (a permanent landmark) in Socorro County (approximately 252 km (157 mi)). Excluded from this designation were the Pueblo lands of Santo Domingo, Santa Ana, Sandia, and Isleta. Because each of these Pueblos submitted management plans that provide for special management considerations or protections for the silvery minnow these lands were not included in the final critical habitat designation. The Service determined that the benefits of exclusion outweigh those of including the Pueblos of Santa Domingo, Santa Ana, Sandia, and Isleta as part of the critical habitat designation. A major factor in this determination was that, even if excluded, these river reaches owned and managed by the Pueblos will nonetheless receive special management and protection through the Pueblos' management plans. Under these management plans, the silvery minnow will benefit from monitoring, restoration, enhancement, and survey efforts. The critical habitat designation also includes a portion of the

Jemez River, a tributary of the Rio Grande north of Albuquerque. Critical habitat includes the Jemez River from the Jemez Canyon Dam to the upstream boundary of the Santa Ana Pueblo (it does not include Jemez watershed lands within the Pueblo).

The width of the critical habitat designation, in areas of the river that are bound by existing levees, is defined as extending to those levees. The designation of critical habitat will not result in the removal of existing levees. While areas outside of the existing levees may be important for the overall health of the Rio Grande ecosystem, these areas have almost no potential for containing the primary constituent elements (see below) because they are separated from the river by the levees and are rarely inundated with water. Therefore, they were not considered essential to the conservation of the species. Nevertheless, these and other areas outside of the critical habitat designation will continue to be subject to conservation actions that may be implemented under section 7(a)(1) of the ESA, the regulatory protections afforded by the jeopardy standard in section 7(a)(2) of the ESA, and take prohibitions in section 9 of the ESA.

In areas without levees, the width of the critical habitat designation is defined as the area of bankfull width plus 91.4 m (300 ft) of riparian zone on each side of the banks. The bankfull width is the width of the river at bankfull stage (the flow at which the river begins to leave the channel and move into the floodplain). Bankfull stage, while a function of the size of the stream, is a fairly consistent feature related to the formation, maintenance, and dimensions of the stream channel. The 91.4 m width defines the lateral extent of the areas believed to be essential to the conservation of the species. Although the Rio Grande silvery minnow cannot be found in these areas when they are dry, they likely provided backwater habitat and were sometimes flooded in the past. Therefore, they may provide habitat during high-water periods.

The 91.4 m width was selected for several reasons:

1. The biological integrity and natural dynamics of the river system are maintained within this area. The floodplain and its riparian vegetation provide space for natural flooding patterns and latitude for necessary natural channel adjustments to maintain appropriate channel morphology and geometry; store water for slow release to maintain base flows; provide side channels and other protected areas for larval and juvenile fish; allow the river to meander within its main channel in response to large flow events; and recreate the mosaic of habitats necessary for the conservation of the species.
2. Conservation of the adjacent riparian zone helps provide essential nutrient recharge and protection from sediment and pollutants, which contributes to successful spawning and recruitment of Rio Grande silvery minnow.
3. Vegetated lateral zones are widely recognized as providing a variety of aquatic habitat functions and values (e.g., aquatic habitat for fish and other aquatic organisms, moderation of water temperature changes, and detritus for aquatic food webs) and help improve or maintain local water quality.

The critical habitat designation takes into account the naturally dynamic nature of riverine systems and recognizes that floodplains (including riparian areas) are an integral part of the stream ecosystem.

Although it was determined that other areas also are essential to the conservation of the Rio Grande silvery minnow, these areas were not designated as critical habitat because of the Service's analysis under section 4(b)(2) of the ESA. That analysis found that the benefits of excluding these areas from critical habitat designation outweighed the benefits of including them. They include the middle Pecos River from immediately downstream of Sumner Dam to Brantley Dam, New Mexico, and the Rio Grande from the upstream boundary of Big Bend National Park to the Terrell/Val Verde Counties' line, Texas. A discussion of the benefits of excluding or including these areas can be found in the 2003 critical habitat designation (68 FR 8088).

1.8.2 Primary Constituent Elements

The area of the middle Rio Grande designated as critical habitat contains the primary constituent elements that are essential to the conservation of the species during some or all of the year, and can provide for the physiological, behavioral, and ecological requirements of the Rio Grande silvery minnow.

The primary constituent elements of critical habitat for the Rio Grande silvery minnow were determined based on several studies of its habitat and population biology (see 68 FR 8088 for a listing of the studies).

The primary constituent elements are as follows:

1. A hydrologic regime that provides sufficient flowing water with low to moderate currents capable of forming and maintaining a diversity of aquatic habitats such as, but not limited to, the following: backwaters (a body of water connected to the main channel, but with no appreciable flow), shallow side channels, pools (the portion of the river that is deep with relatively little velocity compared to the rest of the channel), eddies (a pool with water moving opposite to that in the river channel), and runs (flowing water in the river channel without obstructions) of varying depth and velocity. All of these are necessary for particular Rio Grande silvery minnow life history stages in appropriate seasons. The Rio Grande silvery minnow requires habitat with sufficient flows from early spring (March) to early summer (June) to trigger spawning, flows in the summer (June) and fall (October) that do not increase prolonged periods of low or no flow, and a relatively constant winter flow (November through February).
2. The presence of low velocity habitat (including eddies created by debris piles, pools, backwaters, or other refuge habitat) within unimpounded stretches of flowing water of sufficient length (i.e., river miles) to provide a variety of habitats with a wide range of depth and velocities.
3. Substrates of predominantly sand or silt.
4. Water of sufficient quality to maintain natural, daily and seasonally variable water temperatures in the approximate range of greater than 1^{o} C (35^{o} F) and less than 30^{o} C (85^{o} F), and to reduce degraded water quality conditions (decreased dissolved oxygen).

These primary constituent elements of critical habitat provide for the physiological, behavioral, and ecological requirements of the Rio Grande silvery minnow. The first element provides water of sufficient flows to reduce the formation of isolated pools. This element is essential to the

conservation of the species because it cannot withstand permanent drying (loss of surface flow) of long stretches of river. Water is a necessary component for all life stages and provides for hydrologic connectivity to facilitate fish movement.

The second element provides habitat necessary for development and hatching of eggs and the survival of the species from larvae to adult. Low velocity habitat provides food, shelter, and sites for reproduction, which are essential for the survival and reproduction of Rio Grande silvery minnow.

The third element provides appropriate silt and sand substrates, which are important in creating and maintaining appropriate habitat and life requisites such as food and cover.

The fourth element provides protection from degraded water quality conditions. When water quality conditions degrade (e.g. water temperatures are too high or dissolved oxygen concentrations are too low), Rio Grande silvery minnow are likely to be injured or die.

1.8.3 Consultation Requirement for Critical Habitat

Section 7(a)(2) of the Endangered Species Act requires all Federal agencies to ensure that actions they fund, authorize, or carry out do not destroy or adversely modify critical habitat to the extent that the action appreciably diminishes the value of the critical habitat for the survival and recovery of the species. Individuals, organizations, States, Indian pueblos and tribes, local governments, and other non-Federal entities are affected by the designation of critical habitat only if their actions occur on Federal lands, require a Federal permit, license, or other authorization, or involve Federal funding.

Activities on Federal lands that may affect the species or its critical habitat require section 7 consultation. Actions on private, State, or Indian pueblo and tribal lands receiving funding or requiring a permit from a Federal agency also will be subject to the section 7 consultation process if the action may affect the species or its critical habitat. Federal actions not affecting the species or its critical habitat, as well as actions on non-Federal land that are not federally funded or permitted, will not require section 7 consultation.

1.9 Conservation Efforts

1.9.1 Introduction

Since 1991, NMDGF, the Service, BOR, COE, the University of New Mexico, and the Pueblos of Santo Domingo, Santa Ana, Sandia, and Isleta have cooperated to conduct research and monitor the status of the Rio Grande silvery minnow and the associated fish community and habitat in the middle Rio Grande valley. Studies on the distribution, abundance, life history, and habitat use of the species have revealed much about the biology of the species and its habitat. The results of these studies, essential first steps in conserving the species, are described elsewhere in this document.

These organizations, as well as others, have also initiated programs to stabilize and enhance the species. Pueblos such as Sandia, Isleta, and Santa Ana have cooperated in silvery minnow research and monitoring. The Pueblo of Sandia has cooperated with the Service and BOR in

tagged fish and egg monitoring studies for almost four years and participated in augmentation for the last three. Santa Ana recently signed a Safe Harbor Agreement with the Service for silvery minnow, southwestern willow flycatcher (*Empidonax traillii extimus*), and bald eagle (*Haliaeetus leucocephalus*) and has undertaken habitat restoration efforts to benefit all three species. The Pueblos of Santo Domingo, Sandia, and Isleta have also initiated habitat restoration programs on their lands.

The following sections further describe ongoing conservation actions to benefit the Rio Grande silvery minnow. Several of these efforts were funded or coordinated under the auspices of the Middle Rio Grande Endangered Species Collaborative Program (MRGESCP). This program focuses on the protection and recovery of both the Rio Grande silvery minnow and the southwestern willow flycatcher. Signatories include State and Federal agencies, irrigators, pueblos and tribes (www.middleriogrande.com).

1.9.2 Propagation and Augmentation

The Service and other organizations have cooperated in captive propagation and augmentation. These programs aim to establish refugial populations to prevent the extinction of the species, produce genetically viable captive-bred fish, and augment the wild population, as well as improve propagation and augmentation methods (Remshardt 2008).

1.9.2.1 Egg Collection

Wild-caught Rio Grande silvery minnow eggs have been collected from the middle Rio Grande since 2000 for use in propagation and augmentation programs. Eggs were collected just after the spawn in a variety of locations. Most were collected in the southernmost part of the species' current range, just above Elephant Butte Reservoir; this location allowed for the collection of eggs that had drifted downstream from throughout the current range of the species, thus including a wide range of genetic material. More than 1.1 million eggs have been collected. The City of Albuquerque's BioPark distributes the eggs to State and Federal cooperators after collection and processing (removal of organic debris and estimates of numbers), for future propagation and augmentation efforts. A portion of the eggs are also maintained at the BioPark for grow-out into production fish and broodstock for captive propagation. Since 2005, egg catch rates have been low, so young-of-year fish rather than eggs have been collected from the river for use as broodstock.

1.9.2.2 Captive Facilities

Maintenance of captive stock of the Rio Grande silvery minnow occur at the locations described below. Maintaining specimens at several facilities helps to protect them from extirpation due to unforeseen events.

The **Dexter National Fish Hatchery and Technology Center** in Dexter, New Mexico, (Dexter NFHTC) serves as the lead Federal facility for propagation of the species. Activities include the establishment of an ad hoc propagation and genetics work group, development of a captive propagation plan, refinement of captive propagation and rearing techniques, maintenance and expansion of refugial populations, and research on life history, feed formulation, feeding trials, fish marking, and tag retention. Dexter NFHTC uses modified warm-water fish culture techniques to rear the fish. The Rio Grande silvery minnow

propagation program uses 15 ponds for production fish and three ponds for broodstock, two 2000-gallon recirculation systems with temperature control and independent bio-filtration, ten 3-foot-diameter circular tanks, two 10-foot-rectangular flow-through tanks, and twelve 40-gallon aquaria. The facility annually produces more than 250,000 (>35 mm) Rio Grande silvery minnows for the middle Rio Grande and Big Bend. The propagation program at Dexter NFHTC began in 2001, and has made significant advances in developing appropriate and consistent propagation and culture methods. Dexter NFHTC maintains a captive refugium/broodstock of approximately 15,000 adults from wild collected eggs. The facility relies on egg collections in the middle Rio Grande and captive broodstock to meet targeted augmentation numbers.

The **Rio Grande Silvery Minnow Rearing and Breeding Facility** at the City of Albuquerque's BioPark began experimental propagation of Rio Grande silvery minnow in 2000, in cooperation with the Service. In 2003, the BioPark added new state-of-the-art facilities, including an indoor breeding and hatching system, twelve 20,000-gallon outdoor rearing and holding tanks, and an outdoor naturalized refugium stream, which is used for holding a captive population, spawning, rearing, and research. The facility can annually produce 75,000 fish for augmentation/reintroduction and can hold 30,000 fish as a captive population. It can also process wild-caught eggs and produce eggs and larvae for distribution to other facilities. The naturalized refugium is intended to provide conditions for fish that are more similar to natural river conditions.

The Service's **New Mexico Fish and Wildlife Conservation Office** (NMFWCO) in Albuquerque oversees management activities associated with propagation and augmentation, including development of propagation and augmentation plans, monitoring activities, collection of broodstock for propagation facilities, and transfer between propagation facilities. A 1,000-gallon re-circulating system at the facility is used to seasonally hold juvenile and adult Rio Grande silvery minnow for a variety of purposes, including broodstock maintenance, salvage, and propagation.

The **USGS's Cooperative Research Station** at New Mexico State University facility in Las Cruces, New Mexico has assisted with captive propagation activities since 2001. It's A-Mountain Geothermal Fish Culture and Research Facility participates in captive breeding, rearing, and research activities. This facility has provided space for additional captive breeding and broodstock maintenance, as well as space for research on feed and stress responses.

The **Los Lunas Silvery Minnow Refugium** built and managed by the New Mexico Interstate Stream Commission opened for operation in May 2009. It was designed to provide a naturalized environment for captive silvery minnows. The outdoor refugium is 0.5 acres in size and provides a range of silvery minnow habitat including backwaters and overbank areas. Additionally, the facility has a 1,500 ft^2 indoor holding facility.

The **Rio Grande Silvery Minnow Sanctuary** is located in Albuquerque, New Mexico, and was completed in 2009. The NMFWCO is responsible for long-term operation and management of the sanctuary, with assistance from the Middle Rio Grande Endangered

Species Collaborative Program and U.S. Bureau of Reclamation, Albuquerque. The basis for the sanctuary design is to provide suitable habitat for maintaining Rio Grande silvery minnow. Specific environmental components that may be supported by the sanctuary are self-sustaining food web, spawning habitat, early life stage rearing, and adult habitat. Geomorphic variability of constructed sanctuary habitats, (i.e., sloughs, swales, ephemeral side channels) will allow for habitat diversity and acclimation of captive reared RGSM prior to release.

Several other facilities, including the Mora National Fish Hatchery and Technology Center, the Rock Lake State Fish Hatchery, and the Museum of Southwestern Biology have also assisted with propagation efforts.

1.9.2.3 Propagation Activities

The Dexter NFHTC is the main Federal facility for propagation. Since the program began, survival rates of specimens reared there have increased steadily, rising from 10 percent in 2001 to 85 percent in 2008.

Dexter NFHTC currently maintains a captive refugia/broodstock of 15,000 adult (wild-collected) fish from as many as four year classes at a time. As recommended in the Rio Grande silvery minnow genetics management and propagation plan (USFWS 2009), 10 percent of all wild-collected eggs are maintained as a genetic reserve population. The Dexter NFHTC program relies in part on receiving eggs collected from the annual egg salvage operations on the Rio Grande. When enough eggs are not available through this salvage effort, the staff spawns wild-collected captive broodstock to meet augmentation numbers; this was necessary in 2003 and every year after 2005.

The BioPark began experimental propagation of Rio Grande silvery minnow in 2000, in cooperation with the Service. Experimental propagation concentrated on providing grow-out facilities for wild-caught eggs, inducing broodstock to spawn through injections of carp pituitary extract, and studies concerning captive propagation. In 2001, the level of effort in collection of wild eggs and captive spawning increased, allowing propagation efforts to change from experimental to production (fish were subsequently used to augment the wild population).

In June 2003, the BioPark's naturalized refugium was brought online. This outdoor system is an oval-shaped channel with a volume of 50,000 gallons. It has habitat features including sand substrate, plunge pools, backwaters, runs, and debris piles. Current is generated using a large circulating pump. Flow can be raised to 1.5 feet/second. Spawning in the refugium has occurred on several occasions as a result of an increase in flow and turbidity. The refugium is used primarily for grow-out of fish for augmentation and for holding broodstock.

1.9.2.4 Augmentation Activities

Efforts to augment the wild population of Rio Grande silvery minnow began in May and June 2000 with the release of an estimated 204,000 larval and 414 adult Rio Grande silvery minnow in the middle Rio Grande, near the NM Highway 6 Bridge in Los Lunas and the NM Highway 44 Bridge in Bernalillo, by staff from the University of New Mexico's Museum of Southwestern

Biology. The larval fish were the result of captive spawning of wild adults from the San Acacia Reach (surviving adults were returned to the river after spawning).

Beginning in 2001, NMFWCO and collaborators instituted the Rio Grande silvery minnow augmentation plan (Remshardt 2001) which was revised in 2008 (Remshardt 2008b). To date, augmentation efforts have resulted in the release of more than 1,000,000 Rio Grande silvery minnow. While the primary goal is to augment the wild population with Rio Grande silvery minnow raised from wild-caught eggs, releases have included minnows that were raised from salvaged eggs, wild-caught larvae, as well as minnows from eggs produced by artificial spawning in captivity.

1.9.2.5 Propagation and Augmentation Research

Several of the facilities involved in the propagation and augmentation program have also conducted research studies.

The BioPark has researched methods of artificial inducement to spawn as well as the use of environmental manipulations to induce natural spawning. In 2004, natural spawns at the facility resulted in the production of 200,000 eggs. In 2005, studies produced data on the influence of flow and turbidity on the spawning of Rio Grande silvery minnow. Preliminary results indicate that the species will spawn following a change in either flow or turbidity. Studies included experiments on alternative methods of artificial inducement to spawning and the use of environmental manipulations to induce natural spawning. Studies have also looked at egg and larval developmental rates, and swimming speeds (to provide data for the design and construction of fish passages in the river).

Feed studies to improve survival and performance of captive specimens were initiated at A-Mountain through a cooperative effort with Dexter NFHTC and Bozeman Fish Technology Center. Test diets were formulated by the Bozeman Fish Technology Center, while A-Mountain and Dexter NFHTC served as test sites. Growth was best in juveniles provided with an experimental flake feed (Caldwell et al. 2006, 2010). Swimming stamina challenge tests indicated that fish in captive propagation facilities can be conditioned prior to release into the wild, improving chances for survival.

Currently, all Rio Grande silvery minnow are tagged before release. Several tagging methods have been tested and all specimens now carry Visible Implant Elastomer tags (Remshardt and Davenport 2003). Information from recapture of tagged individuals is being used to determine the effects of different release protocols on survival. Laboratory studies indicate that Visible Implant Elastomer tag retention rates are generally high, ranging from 98-100 percent for up to one month and 77-82 percent for three to six months.

1.9.3 Habitat Restoration

1.9.3.1 Habitat Restoration Plan

A framework habitat restoration plan for the middle Rio Grande has been developed (Tetra Tech EM Inc. 2004). The restoration plan serves as a guide for implementing restoration activities

throughout the silvery minnow's occupied range. Also, the restoration plan emphasizes the importance of improving egg and larval retention and addressing habitat fragmentation.

The restoration plan outlines a "suite of actions" that will be needed in order for habitat restoration efforts to be successful:

- sustained flows to promote sufficient populations of wild fish
- spring flow peak in mid- to late-May to stimulate spawning
- establishment of channel conditions that retard downstream displacement of eggs and larvae
- establishment of a sustainable population of Rio Grande silvery minnow in the Angostura reach
- establishment of suitable feeding and cover habitat for juveniles and adults
- remediation of longitudinal discontinuity associated with irrigation diversion structures

The restoration plan also describes some of the specific restoration techniques that could be considered for future Rio Grande silvery minnow habitat restoration projects. These include:

- passive restoration
- terrace and bank lowering
- high-flow, ephemeral side channels
- high-flow, bank-line embayments
- arroyo connectivity
- main channel widening
- removal of lateral confinements
- river bar and island enhancement
- destabilization of islands and bars
- gradient-control structures
- woody debris
- sediment management
- fish passages

1.9.3.2 Completed Habitat Restoration Projects

Numerous habitat restoration projects have been completed in the middle Rio Grande. Projects have been funded by many organizations including the MRGESCP (www.middleriogrande.com), Middle Rio Grande Bosque Initiative (http://www.fws.gov/southwest/mrgbi/) and the COE (http://www.spa.usace.army.mil/). Examples of completed projects include:

- The Los Lunas Habitat Restoration Project involved removing jetty jacks along 6,000 feet of river bank, lowering 50 acres of river bank, contouring to integrate floodplain functions, and construction of side channels, wetlands, and other features.
- Inlets were added to the River Widening Project at Bosque del Apache National Wildlife Refuge for minnow habitat.
- The Pueblo of Santa Ana is creating over 100 acres of riparian wetland habitat along the active floodplain, 40 of which are complete. More than 725 acres of cottonwood bosque have been restored through the clearing of salt cedar and Russian olive (a total of 1,300 acres are slated for restoration). The Pueblo has also worked to restore the geomorphology of six river miles traversing the Pueblo including the installation of three gradient restoration facilities, each of which provides a 500 feet long fish passage apron.

- The Pueblo of Sandia, in cooperation with the Service's Management of Exotics for Endangered Species Recovery program, cleared and revegetated 29 acres of bosque and completed in-channel modifications to an adjacent 10 acres island/bar.
- A river bar modification project just south of I-40 Bridge involved the construction of side and backwater channels on an existing bar as well as modification of the top surface of the bar to create habitat over a range of flows.
- Two woody debris installation projects have been conducted in the Albuquerque Reach to encourage the development of pools and wintering habitat. Cottonwood snags and woody debris of various sizes have been used and are being monitored.
- At the Rio Grande Nature Center, the COE created a high-flow side channel (3 acres) that reconnects the Rio Grande with the bosque, and 10 acres of exotic vegetation removal and native shrub plantings.
- The Interstate Stream Commission has completed several habitat restoration projects in the Albuquerque and Isleta Reaches. These projects total approximately 257 acres and include such features as backwaters, embayments, scoured and terraced banklines, modified islands, ephemeral channels, lateral constraint removal (e.g., jetty jacks), placement of large woody debris to create scour flows, and floodplain vegetation management.

1.9.4 Water Management

Water management in the middle Rio Grande valley has advanced significantly over the past five years with the recognition that the available surface water supply is insufficient in many years to meet all demands. Given the drought, research on historical flows and climate, and daily observation and management of river flows and reservoir releases over the past few irrigation seasons, water managers now have a better understanding of the variability of the natural system and how to manage releases of stored water to better maintain flows at specific points along the river.

1.9.4.1 Background

In the late 1990s, and perhaps until experiencing the dry year of 2000, the implicit assumption regarding the surface water supply of the middle Rio Grande basin was that the available supply was sufficient on a year-to-year basis to meet all existing demands. In fact, as described below, the surface water supply to the middle Rio Grande valley is not sufficient to do so, especially during drought periods (S.S. Papadopulos & Associates, Inc. 2001, 2002).

From the late 1970s through the mid-1990s, surface water supply was approximately 20 percent higher than it had been in the preceding two to three decades. The surface water supply in that period has been reported to be among the wettest in the last 1,000 years (based on tree-ring data). From the available record, the basin appears to experience wet and dry periods on a 50-70-year cycle. The wet periods (such as the late 1970s through mid-1990s) can be 15-30 percent wetter than the long-term average, while the dry (below average) periods can be 15-30 percent drier (S.S. Papadopulos & Associates, Inc. 2001, 2002). During the last significant drought period (1950s), the available gage record indicates that the Rio Grande dried south of Albuquerque in multiple years and on as many as 100 days in one year. The drying experienced during those periods in the Isleta and San Acacia reaches significantly exceeded that of the Albuquerque reach (USGS 2001).

Natural surface water supplies in the middle Rio Grande are highly variable from year to year. Annual flow volumes of native Rio Grande water as measured at the Otowi gage have measured as low as 250,000 acre-feet to over 2,000,000 acre-feet (USGS 2001). The distribution of flows is skewed, with a few high years significantly affecting the mean. The vast majority of the native flow at Otowi during a water year (October 1 through September 30) occurs March through June and accounts for about 60 percent of the annual total flow. About 20 percent of the annual native flow occurs from November through February, the rest from July through October.

1.9.4.2 Water Management Actions to Meet Biological Opinion Flow Targets and Requirements

Specific water management actions have been used to meet middle Rio Grande valley river flow targets, manage river recession, and generate the spawning spikes specified in the Service's Biological Opinion for water operations and flood control (U.S. Fish and Wildlife Service 2003), including:

- interagency coordination of daily river and reservoir operations
- improvements to irrigation metering and management
- indirect use of native Rio Grande water (both stored and direct flow)
- release of stored San Juan-Chama Project water and use by exchange
- direct use of stored native Rio Grande water made available by the State of New Mexico
- pumping from the Low Flow Conveyance Channel to the river

1.9.4.3 Summary

The water management agencies responsible for the middle Rio Grande have been successful in recent years in implementing a number of innovative and flexible operations and programs to assist with meeting the needs of water users, including the Rio Grande silvery minnow. Those operations and programs have been successful primarily due to two sources of water that most likely will not be available in coming years: San Juan-Chama Project water and New Mexico accrued credit water.

With the exception of 2,990 acre-feet of San Juan-Chama Project water reserved for use in Indian water rights settlements, the entire firm yield (96,200 acre-feet) of the project is under contract. A substantial amount of that water has been surplus to the needs of the various contractors until recently, and many are now implementing plans to fully use their allocations. The State of New Mexico in recent years has enjoyed a substantial surplus of accrued credits under the Rio Grande Compact and has made that source of water available to the United States through the Conservation Water Agreement and the Emergency Drought Water Agreement, to assist with meeting the flow targets and water management operations required by Biological Opinions. The Conservation Water Agreement and Emergency Drought Water Agreement are unique in the history of State/Federal relationships during implementation of the requirements of the ESA.

1.9.5 Salvage

Over the last several years, dry conditions on the middle Rio Grande have led to several periods of river "intermittency," or discontinuous flow. When such conditions occurred, it was necessary to conduct emergency salvage operations to move Rio Grande silvery minnow from

isolated pools in drying areas to stretches of the river that were still flowing, in order to reduce mortality. Typically, the fish were relocated from a drying downstream region of the middle Rio Grande to wetter upstream areas. River intermittency usually occurs between July and October.

In the late 1990's, informal salvage operations relocated an estimated total of 11,000 individuals (adults and juveniles) from isolated pools in the San Acacia Reach upstream to several locations within the Isleta and Angostura reaches. Since 2001, Rio Grande silvery minnows have been rescued under a formal program administered by the Service as required by the 2003 Biological Opinion (U.S. Fish and Wildlife Service 2003). Initially, this program sought to collect and transport all stranded silvery minnow from drying reaches to the Angostura Reach.

Research on the cumulative effects of intermittency, capture, and transport of salvage found greater physiological stress responses and lower survival of salvaged fish compared to fish collected from perennial areas (Caldwell and Remshardt 2008). The cumulative effects of intermittency likely increase the silvery minnow's susceptibility to disease as well as increase the chances of exposure to opportunistic pathogens (Caldwell and Remshardt 2008).

In 2007, in response to researchers' concerns about disease transport across reaches, the salvage protocol changed. Now, salvage activities concentrate on newly (on an annual basis) intermittent stretches of river where salvage would minimize incidental take and survival of salvaged fish would be highest. In the instances where salvage is deemed necessary and feasible, every effort is be made to ensure that any fish to be moved have the highest probability of survival, but only to flowing sections within the reach from where they were salvaged. Included in the protocol was a Hazard Analysis Critical Control Point Plan to remove or reduce the risks of introducing hazardous non-target species of plants, animals, and pathogens into new locations associated with salvage activities.

1.9.6 Reintroduction

The final rule regarding the Service's plan to reestablish the endangered Rio Grande silvery minnow in the Big Bend reach of the Rio Grande in Texas under a 10(j) non-essential experimental population designation was published in the Federal Register on December 8, 2009 (73 FR 74357) (Figure 2). The Service with the assistance of many partners released approximately 445,000 silvery minnows at 4 sites in the Big Bend reach on December 16 and 17, 2009. The release was the first of many and is an important step in fulfilling the recovery goals identified in this Rio Grande Silvery Minnow Recovery Plan.

Quarterly monitoring of silvery minnows in the Big Bend reach began in May 2009. Adult Rio Grande silvery minnow were found at all four release sites, indicating that at least some and likely many of the fish released in December survived over the winter and are a component of the fish community within the Big Bend reach of the Rio Grande. Fish were in fair to good condition and in varying stages of reproductive development. No pathogens were detected in samples collected for standardized fish health diagnostics. The monitoring crew also captured large numbers of other native fishes, including blue sucker (*Cycleptus elongatus*), speckled chub, and longnose dace, suggesting that many fish benefitted from the recent record level of flooding in the fall of 2008. It will take years of monitoring to fully evaluate if the species is established and will remain viable in this river reach. Current plans are to release Rio Grande silvery

minnow into Big Bend for a minimum of five years. Following the initial five-year period, the Service anticipates monitoring and releasing Rio Grande silvery minnow into this area until either: (1) a self-sustaining population of silvery minnow is established in the Big Bend Reach, or (2) the reestablishment of silvery minnow in potentially suitable habitat becomes highly unlikely.

1.9.7 Summary

Although various conservation efforts have been undertaken in the past and others are currently being carried out in the middle Rio Grande, and abundance in recent years is increasing, the threat of extinction of the Rio Grande silvery minnow continues because of the high probability of continued drought, the fragmented and isolated nature of currently occupied habitat, and the absence of silvery minnows in other parts of the historic range. Additional work needs to be done to conserve this species and the ecosystems upon which it depends

1.10 Tribal Perspective on Rio Grande Silvery Minnow Management and the Endangered Species Act

The following section was prepared by the Tribal Subgroup of the Rio Grande Silvery Minnow Recovery Team. It is important to note that while most, if not all, of the Indian sovereigns within New Mexico have interests in and will be affected by the ongoing efforts to protect and recover the species, each Indian sovereign will choose its level of partnership and participation in those efforts, and that nothing in this recovery plan creates duties, obligations, or commitments enforceable upon any of those Indian sovereigns.

1.10.1 Introduction

To speak with one voice for all the Indian tribes in the southwest region of the United States that have a stake in Rio Grande silvery minnow management and the recovery of endangered species is not possible (Figure 6). There are probably as many approaches to this issue as there are tribes. It is possible that many tribes, beyond disagreeing with the notion of acceptance of and cooperation with the ESA, would be hesitant to even participate in this dialogue. Therefore, this paper in no way intends to speak for every tribe in the United States or even in the southwest region. Instead, the ideas presented here represent a consensus among some tribes that believe there is room for dialogue with the Service on ways to improve the Federal/Tribal relationship as it relates to endangered species management. Many of the problems surrounding this issue remain extremely sensitive and contentious. Therefore, there is a need for the Federal government, including the Service to establish more effective relationships with the tribes, based on mutual respect for each other's needs and the desire to move beyond an adversarial relationship to a problem-solving approach.

1.10.2 Background

Before Tribal involvement in the Rio Grande silvery minnow recovery is discussed, it is important to provide some background on the ESA as it relates to tribal interests. Before this is possible, however, some history of the Federal/Tribal relationship is necessary. This relationship is built on the U.S. Constitution, multiple U.S. Supreme Court decisions, Federal statutes, and

executive orders and policies of several Presidential administrations. By far, the most important and pervasive of these concepts are Tribal Sovereignty and Trust Responsibility.

1.10.2.1 Tribal Sovereignty

The inherent sovereignty of Indian tribes and nations has long been recognized by the United States Constitution, the Federal government and Federal courts. See Cherokee Nation v. Georgia (1831); United States v. Winans (1905) (Indian nations reserve all governmental powers and individual rights not specifically abrogated by Congress, or granted away by the tribes in their treaties or agreements with the United States). As a result of that Constitutionally established government-to-government relationship, the Federal government has a responsibility to protect Indian trust resources (Indian trust resources generally include land, water, air, minerals, and wildlife, reserved or otherwise owned or held in benefit for Indian pueblos, nations and tribes). That legal principle has been reiterated extensively in recent years within the context of natural resource management, Parravano v. Babbitt (1995) (Federal Indian trust responsibility extends not just to the Interior Department but attaches to the Federal government as a whole), Covelho Indian Community v. FERC (1990) (as a Federal agency, FERC is subject to the Federal Indian trust responsibility . . . that responsibility is to be executed to the highest standards of fiduciary conduct).

As sovereign nations, tribes and tribal lands are not subject to the same public laws that govern other lands within the United States, either public or private. It has been legally established that inherent in the establishment of a reservation is the right of Indians to hunt and fish on reservation lands free from State regulation. Cases such as Menominee Tribe v. the United States (1968), Washington v. Passenger Vessel Association (1979), New Mexico v. Mescalero Apache Tribe (1983), Arapahoe Tribe v. Hodel (1990), and Minnesota v. Mille Lacs Band of Chippewa Indians (1999) have cemented this precept. Some of these rights are based on treaty rights, but many follow from the mere establishment of a reservation and the self-governance powers inherent therein. Congress may limit the powers of Indian self-governance including the denial of treaty established hunting or fishing rights as it did when it prohibited Indians from hunting eagles under the Eagle Protection Act. But to do so, the Congressional act abrogating those powers must be clear and explicit (see Lone Wolf v. Hitchcock 1903). Absent clear Congressional intent, however, tribal self-governance and their retained rights and powers are not extinguished and may be upheld even if they affect off-reservation lands (including both public and private land) where a tribe has a treaty established or other federally recognized interest (see Winters v. United States 1908, United States v. Winans 1905). In general, however, Congress has not abrogated tribal interests and utilization of Indian trust resources and the matter has been, for the most part, left to tribal regulation.

Although Congress does have authority to restrict some tribal wildlife practices, it is unclear whether the Service and the U.S. National Marine Fisheries Service (the two agencies responsible for enforcing the Act) have authority to enforce the ESA on tribal land; the issue has never been decided by the courts. At the heart of the matter is the question of what Congress' intent was when it established the ESA. The ESA does not specifically mention tribes, and other court cases have upheld the concept that, unless tribal treaty and other rights are specifically abnegated by an act of Congress or a particular piece of legislation, they remain in force. In the one court case, United States v. Dion, a tribal member was convicted of taking a bald eagle for

commercial use. The statute under which the case was prosecuted, however, was not the ESA, but the Eagle Protection Act. The ESA question was left unanswered.

Given this ambiguity (not to mention the potential for costly and lengthy litigation), many tribal leaders and natural resource managers would prefer to work out these conflicts with cooperative agreements with Federal and State officials rather than through the courts.

All of the above is not to imply that all Indian tribes are unwilling to work with the ESA or even see it as a burden. In fact, some tribes have used the ESA to benefit them, especially in regards to the protection of dwindling fish stocks in the Pacific Northwest and the Great Lakes region. For example, the Pyramid Lake Paiute Tribe in Nevada and other entities used the ESA to achieve listing of the Cui-ui sucker in Pyramid Lake, and to protect water resources and reduce diversions from the Truckee River. In the Pacific Northwest, off-reservation treaty fishing rights are often protected by mandatory conservation measures, which are backed with the strong arm of the ESA.

All this legal maneuvering does little to help endangered species. Consequently, a dialogue has arisen between some tribes and the Service about whether it is possible to set aside differences over interpretation of the ESA and other laws and instead concentrate on cooperative policies that can be adopted to help endangered species and their habitat.

1.10.2.2 Trust Responsibility

As shown by the preceding section, it is well established that Indian tribes in the United States are sovereign entities, and that the United States government is legally required to protect Indian trust resources for the benefit of the respective Indian pueblos, nations, and tribes. Those legal duties ultimately are intended to ensure that Indian lands remain capable and sufficient of serving as viable homelands for the respective tribes. In managing trust lands or assisting tribes in doing so, the government must act for the exclusive benefit of the tribes, and ensure that Indian lands and resources are protected and maintained for the physical, economic, social, and spiritual well-being of tribes. Tribal lands are not Federal lands and are not set aside or designated for a primary purpose of wildlife refuge, critical habitat for endangered species, or for the protection of other flora or fauna except as it may directly benefit the tribe. As a practical matter, tribal lands comprise some of the most wild and most scenic places on the continent and tribal lands in many cases support a far greater biological diversity than the surrounding public or private lands.

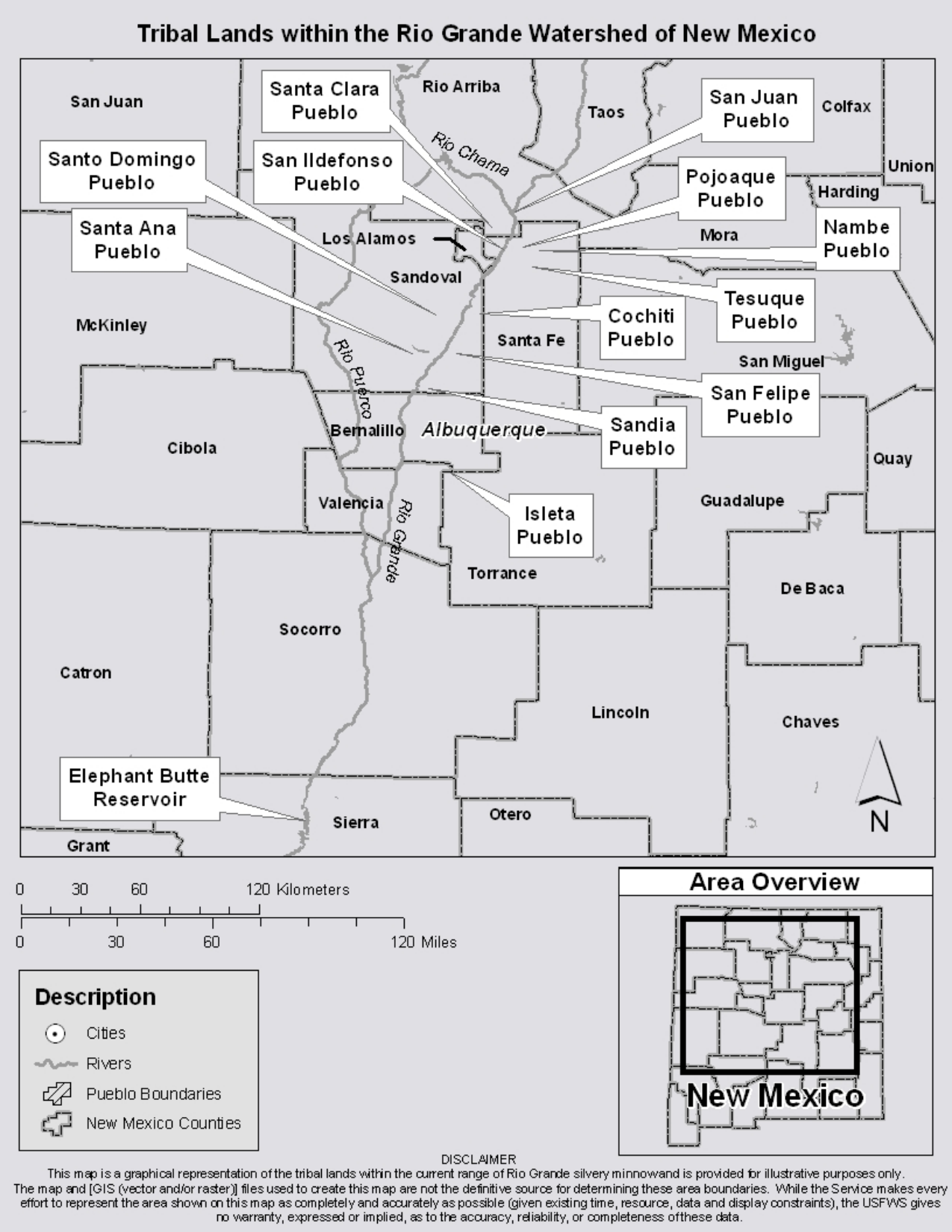

Figure 6. Tribal lands within the Rio Grande watershed of New Mexico.

Nevertheless, tribal lands are first and foremost homelands to Indian people, established to provide for their traditional, cultural, social, and economic benefit.

The interaction of tribal sovereignty and trust responsibility is complex as tribes and the government struggle to protect Indian trust resources while at the same time respecting the tribes' powers to manage their own affairs. As a result, several Executive Branch administrative directives and orders bear directly on the relationship of the Service and other Interior Department agencies to tribes. The following are examples of these directives and orders (the full text of some of these directives can be found in the appendices):

1.10.2.2.1 Secretarial Order 3175 (November 8, 1993) and Interior Department Manual 512 DM2 - These documents require all Interior Department agencies to identify potential effects from their activities on Indian trust resources and to have meaningful consultation with tribes where Department activities affect tribal resources, either directly or indirectly. This Order also directs Interior agencies to remove procedural impediments to working effectively with tribal governments, to consult with tribes on a government-to-government basis where trust resources are affected, and to identify potential effects on Indian trust resources of Department's plans, projects, programs, and activities.

1.10.2.2.2 Presidential Memorandum of April 29, 1994 - This document reasserts the Federal Indian trust responsibility and requires that all Executive Branch departments and agencies implement their activities in accordance with the government-to-government relationship between Indian tribes and the United States. It requires these departments to consult with tribal governments to the greatest extent practicable prior to taking actions that affect tribal governments, to assess the impact of Federal activities on tribal trust resources, and to ensure that tribal rights and concerns are taken into account during plan development and program implementation (see Appendix A).

1.10.2.2.3 The Native American Policy of the U.S. Fish and Wildlife Service, June 28, 1994 - This policy reiterates the government-to-government relationship and establishes a framework for joint projects and formal agreements. It also directs the Service to assist tribes in identifying Federal and non-Federal funding sources for wildlife management activities, and provides a framework for the Service to give technical assistance to tribes, where requested. While the Service has been helpful to tribes from a technical standpoint, many tribes feel that funding for tribally-related wildlife protection activities has been limited and difficult to acquire. The Partners for Fish and Wildlife program has provided some funds, but these are often for small-scale projects.

1.10.2.2.4 Joint Secretarial Order 3206, June 5, 1997 - This is perhaps the most far-reaching of the Executive Branch directives and has been very well received by most tribes (see Appendix B). It also has potentially the greatest impact on how tribes and the Federal government manage endangered species. The Order recognizes the value of cooperation between Federal and tribal governments. It also recognizes the jurisdictional tensions inherent in Indian trust resources management. In order to strike a workable balance, the Secretarial Order specifically states that it "shall not be construed to grant, expand, create, or diminish any legally enforceable rights, benefits, or trust responsibilities . . . under existing

law", while making clear that it "does not preempt or modify the [U.S. Fish and Wildlife Service's] statutory authorities." It reaffirms the trust and treaty responsibilities of the U.S. government and instructs Federal agencies to "be sensitive to Indian culture, religion, and spirituality." It also reminds Interior departments that Indian lands are not subject to the same controls as Federal lands; instructs them to recognize that tribes are the appropriate governmental entities to manage their lands and resources; and instructs them to support tribal measures that preclude the need for conservation restrictions. At the same time, the Order strives to harmonize tribal concerns and interest about the ESA with Federal mandates to enforce it; and it allows for the tribes to develop their own conservation plans for listed species that are more responsive to tribal needs.

The Order states, "The departments shall work directly with Indian tribes on a government-to-government basis to promote healthy ecosystems…Accordingly, the departments shall seek to establish effective government-to-government working relationships with tribes to achieve the common goal of promoting and protecting the health of these ecosystems." Whenever the agencies, bureaus, and offices of the departments are aware that their actions planned under the Act [ESA] may impact tribal trust resources, the exercise of tribal rights, or Indian lands, they shall consult with, and seek the participation of, the affected Indian tribes to the maximum extent practicable. This shall include providing affected tribes adequate opportunities to participate in data collection, consensus seeking, and associated processes."

"…Accordingly, the Departments will carry out their responsibilities under the Act [ESA] in a manner that harmonizes the Federal trust responsibility to tribes, tribal sovereignty, and statutory missions of the Departments, and that strives to ensure that Indian tribes do not bear a disproportionate burden for the conservation of listed species, so as to avoid or minimize the potential for conflict and confrontation [emphasis added]."

1.10.2.2.5 Executive Order No. 13084, May 14, 1998 - This Presidential Order instructs all executive branch agencies to establish a process whereby elected officials and other representatives of Indian tribal governments may provide meaningful and timely input into the development of regulatory policies and matters that significantly or uniquely affect their communities. Interestingly, it also instructs agencies, to the extent practicable and permitted by law, to consider any application by a tribal government for a waiver of statutory or regulatory requirements with a general view toward increasing opportunities for flexible approaches to governmental policies. This opportunity for administrative flexibility has the potential to play a key role in how the Service implements endangered species recovery.

1.10.3 Tribal Concerns about the Endangered Species Act

Indian tribes often work closely with the Federal government to meet many natural resource management needs; therefore a wide array of activities on Indian lands can trigger Federal regulation, including ESA section 7 consultations. Consequently, nearly every type of federally-funded or federally-approved activity requires consultation measures of one sort or another. While the intent of these regulations is to protect federally-listed threatened and endangered species, the regulatory processes can occasionally create a bureaucratic quagmire that can

impede projects and conflict with tribal economic development, which has often lagged behind that of non-Indian communities.

In recent years, many tribes in the United States have become wary of the intent of the ESA and the manner in which it is applied on tribal lands. Many tribes feel that they have been far better land stewards than the vast majority of private landowners and even some Federal land management agencies, and consequently have a higher proportion of endangered species on their land. In addition, most tribal lands are far less developed (i.e., have a higher proportion of rangelands, forests, or de facto wilderness) than surrounding private or public land. This means that tribal lands have the potential to act as a safe haven for some endangered or rare species, which are driven off surrounding private land as it is developed. Tribes feel that they have been penalized for this good stewardship by having restrictions placed on development activities, and being told what they can and cannot do on their own land, which is viewed as a direct affront to tribal sovereignty. While tribes want to keep vast areas of resource use on their lands, they do not want to be penalized for not having "urbanized" yet.

A more far-reaching concern of tribes is the use of certain federally protected species for religious, cultural, or ceremonial purposes. As an example, considerable conflict has arisen in the past about Indian use of eagle feathers. Some cases have been decided in Federal courts including the U.S. Supreme Court. Nearly all Indian tribes in the United States revere bald and golden eagles and use the birds' feathers or other parts in ceremonies or dances. Bald eagles are federally listed leading to additional restrictions on its take, beyond the Migratory Bird Treaty Act and Bald Eagle Protection Act. Currently, individual tribal members must apply to the Service through the National Eagle Repository to obtain eagle carcasses and feathers, a process that can take as long as 3 to 4 years. While many tribal members understand the need for this process, others view it as a direct affront to religious freedom and feel frustrated by the delays entailed in applying for an eagle. In the past, some latitude has been given to tribes to take such species, although any take may be considered a violation of the ESA, The Migratory Bird Treaty Act, The Lacey Act, or other Federal or State wildlife laws. Again, court cases have led to conflicting interpretations about the circumstances under which a tribe or individual tribal member can "take" a species for cultural or religious purposes, and the type of permit needed. Some tribes are working cooperatively with the Service to allow some of these activities.

Within the context of the ESA, many previous endangered species recovery plans have done an inadequate job of integrating tribal concerns. While some tribes were included at the level of "stakeholders" or "interested parties," their participation, comments, or suggestions carried little, if any weight, in the development of recovery plans. For example, the Tulalip Tribes of the Pacific Northwest have charged that they were largely ignored in the section 7 consultation process during the development of a major habitat conservation plan. Several tribes in the southwest were upset to find that critical habitat for the Mexican spotted owl had been proposed on tribal land without prior consultation. Critical habitat for Rio Grande silvery minnow was also proposed on pueblo lands in New Mexico despite the objections of tribal leaders, and the Service set forth on a path for Rio Grande silvery minnow augmentation plans affecting pueblo lands without any prior consultation with the affected pueblos. Many other examples exist where tribes were inappropriately brought into the endangered species recovery process due to a lack of meaningful consultation and inadequate time for the review of proposed actions.

Instances such as these may have been more appropriately handled simply through better communication. Many tribes are striving to alleviate some of these communication problems through increased cooperation.

1.10.3.1 Endangered Species and Tribal Water

Tribes continue to closely monitor the potential ramifications of Rio Grande silvery minnow recovery on water rights, water availability, and water use. Like all governments, and many private landowners, tribes make active use of the region's limited water supplies for economic development, municipal requirements, farming, ranching, and recreation. Most importantly, the pueblos/tribes continue to have a unique and spiritual relationship with the Rio Grande, which emphasizes their strong traditional and cultural ties to the river. In a region where water is limited, yet vital to the needs of many, battles over who controls how much water are inevitable. Tribes along the Rio Grande continue to be involved in issues surrounding other endangered species, like the southwestern willow flycatcher, and while they are generally supportive of the conservation of ecosystems upon which endangered species depend, they are nevertheless wary of being forced to shoulder a disproportionate share of the burden for their recovery.

For tribes, the issues surrounding the recovery of the Rio Grande silvery minnow including the requirements of ensuring sufficient water to sustain the species are inextricably linked to water rights. In all but a few instances in the southwest, Indian water rights are senior to those of all other users. Specifically, water rights for Indian pueblos in New Mexico include congressionally established, historic use, federally-reserved (Winters Doctrine) and, in some instances, contractual water rights, most of which are vested, recognized, and protected under Federal law. The lack of funding, as well as the complicated and cumbersome process of water rights negotiations, means that significant water rights claims within many basins and river systems are largely unadjudicated. Despite this, water development and management have continued to rapidly expand through the construction of dams and reservoirs, diversion structures, irrigation systems, and municipal water use facilities. When and if water rights within the Rio Grande basin are adjudicated, it is clearly the intent of the tribes to advocate for and secure their rights to sufficient quantities of water required to sustain their reservations as permanent homelands for their current tribal members and for future generations.

Indian water rights are not subject to forfeiture due to non-use, and thus may be exercised at any time in the future, while still retaining their senior priority. The use of water in the Rio Grande by Indian tribes has not contributed to the decline of species. As tribes continue to use their vested federally-reserved and aboriginal water rights, they are sometimes criticized for exercising these rights. According to some endangered species proponents, tribal/pueblo use of water could negatively affect listed species. It is inevitable that as pueblos/tribes continue to embark on new economic development on their lands, there will be growing demands on limited water resources in the Rio Grande basin. It is also likely that as tribes secure their rights to the water within the Rio Grande they will become a significant factor in sustaining river flows and as a result may directly and indirectly contributes beneficially to the ecological integrity of the Rio Grande.

1.10.3.2 Federal/Tribal Cooperation on Endangered Species

The diversity of opinion about Federal/tribal relations has led to a contentious history of differing interpretations over Federal/tribal resource jurisdiction. Nevertheless, the Service and many tribes have expressed a willingness to work together on endangered species issues. Within the last few years, many tribes have gained considerable natural resource management expertise and the Service and other Federal agencies are now recognizing and acknowledging this expertise. Tribes have benefited substantially by having more opportunities to directly participate on a broader level in various work groups and collaborative efforts administered by Federal agencies such as BOR, the Service, and the U.S. Environmental Protection Agency (EPA). Many Federal agencies have established Native American Liaison positions and now offer entire tribal programs. The overall intent of recently issued Federal directives is to establish policies whereby input from tribes can become a regular and critical part of resource planning initiatives, and to encourage more tribal participation. Tribes welcome these changes, utilizing them when it is in their best interest.

Some tribes have moved forward in an effort to establish new parameters in the way Indian nations and the Service interacts regarding issues of mutual concern. The Pueblo of Santa Ana has executed a Safe Harbors Agreement with the Service, the first in the United States between the Service and an Indian tribe. The White Mountain Apache Tribe, San Carlos Apache Tribe, Tohono O'odham Nation, and Pueblo of Zuni have established Statement of Relationships (SORs) with the Service. All these activities have served as models for other Pueblos/Tribes/Indian Nations. These documents establish a framework by which the Service and the tribes will recognize differences of opinion and interpretation, and will work through problems toward a common goal of promoting biodiversity and healthy ecosystems. The Pueblo of Santa Ana's Safe Harbors Agreement recognizes the Pueblo's intensive efforts in restoring its ecosystem, its partnership with the Service in significantly increasing and improving endangered species habitat, and the Pueblo's primacy in managing its resources for ecosystem enhancement and sustainability. The SOR reaffirms tribal sovereignty, while recognizing the Service's technical expertise and willingness to assist tribes with complex management issues. These initiatives have become possible in part because tribes have invested in and increased technical capabilities and infrastructure, and as a result a new framework for open dialogue has been developed. Tribes are now encouraged that many of the issues that they have been advocating are now being taken seriously. Central to this approach is the Service's use of some of its administrative flexibility to work with tribes and establish mutually satisfactory solutions to controversial resource management issues. One example of this approach is the Pueblo of Zuni's construction of the first Native American-owned eagle aviary to alleviate the wait for eagle feathers for tribal members. Through the cooperation and assistance of the Service, permits were obtained within a reasonable time frame. Another example is the Service acknowledging the White Mountain Apache Tribe's inherent right to manage its natural resources, including endangered species. This acknowledgement has supported the tribe's pro-active approach to addressing endangered species on tribal lands, which includes the development of management plans and integration of the ESA in their overall natural resource goals and objectives. Because these proactive approaches strengthen tribal self-sufficiency and sovereignty, other tribes throughout the southwest are considering adopting these approaches to help resolve ESA issues on tribal land. These are good examples of how the Service can utilize its administrative flexibility to assist tribes in adopting a unique and innovative solution to a unique problem.

Tribes are now striving to have a greater voice in endangered species recovery. When the initial steps were taken toward a recovery plan for the southwestern willow flycatcher, tribes expressed dismay at the lack of direct tribal involvement. Tribes believed that their voices were being unduly diluted; given the potential effect recovery efforts for the flycatcher could have on tribal land. This issue was later rectified by the formation of a tribal subgroup. Learning from that experience, the Service created a tribal subgroup as part of the Rio Grande silvery minnow recovery team, with the responsibility to interject tribal perspectives into the Rio Grande silvery minnow recovery plan. Under Secretarial Order 3206, tribes have considerable authority to manage endangered species on Indian lands. Under the auspices of tribal sovereignty, individual tribes have more authority to manage endangered species than the individual states. If a tribe is not satisfied with the process, it can choose not to participate and instead develop its own plan. Given the tentative nature with which tribal leaders and land managers have approached endangered species issues, there are several reasons why the Rio Grande silvery minnow recovery plan gives us cause for optimism. The goal of the recovery process is not only higher populations of this fish but also restored riverine habitat. For many tribes in the southwest, rivers and streams that cross their land provide critical areas for traditional plant and animal collection, recreation, and cultural and religious use. Tribes see riparian and riverine protection as an excellent long-term goal. In only a few generations, tribes have seen these areas severely degraded, mainly from human-induced changes. Some of these changes have unquestionably provided benefits to tribes, although the tribes had no say in the activities. To restore riparian and wetland habitat and to improve this critical ecosystem may be a goal that all tribes in the region can support if the Service is respectful of tribal sovereignty throughout the recovery process for the Rio Grande silvery minnow.

Tribal leaders, as well as tribal resource managers, have been tentative in their approach to endangered species issues. Concerns that tribes have with endangered species conservation include infringement on their status as self-sufficient, sovereign nations by being forced, either directly or indirectly to protect, conserve, and manage their resources for the benefit of federally-listed species. As a result of tribes complying with the ESA, the management of tribal natural resources for the expressed benefit of its tribal members could be potentially compromised. The goal of the recovery process, of course, is not only to restore endangered species populations, but also to improve their habitats. In situations where water is a key element to species recovery, such as is the case for the Rio Grande silvery minnow and the southwestern willow flycatcher, tribal involvement in the conservation of these species may be vital to their continued existence.

1.10.4 Future Needs and Directions

The current climate presents opportunities for significant improvement over what has been a contentious history. The Service and other Interior agencies have considerable administrative flexibility to work cooperatively with tribes and more actively seek their input and guidance when dealing with endangered species and other region-wide initiatives. Some of the Executive Orders and Directives instruct agencies to use this flexibility. It should be remembered that even if a project or consultation may not appear to affect a tribe's resources, there may be aspects of the situation that are not immediately apparent. These include recognition of all tribal water rights, including but not limited to Prior and Paramount and aboriginal water rights, water quality

standards, water management, and traditional and cultural resources that may give a tribe a stake in the management of these resources outside of trust lands.

The Service has taken great strides to achieve concrete results. Tribes applaud the appointment of several tribal members to serve as Native American Liaisons within the Service, and the creation of Interior Department directives, which are favorable to a more cooperative relationship.

1.10.4.1 Recommendations for Enhancing Meaningful Tribal Participation in Relation to the Endangered Species Act

1. Ensure Effective Communication. Many of the past problems outlined in this paper could be avoided with early, open, and honest communication. As stated in Secretarial Orders 3206 and 3175, tribes must be kept involved and informed at all levels and treated as equal partners. To accomplish this, tribes must be involved at the earliest stages of planning; contact with tribes should be frequent; any and all related information must be provided to the tribes for their review; appropriate contacts at all levels must be maintained; and finally, tribes must have sufficient time to review, discuss, and have the opportunity to engage in formal government-to-government consultation. Agencies are reminded that Indian tribes and tribal leaders shall not be viewed as part of the general public, but rather must be dealt with on a government-to-government basis. Agency personnel who are required to communicate and maintain working relationships with tribes must have appropriate training and knowledge in tribal communication protocols; and because all tribes are unique, it is important that individuals be aware of each tribe's culture and customs. The Service should err on the side of consulting and communicating with tribes prior to taking action, rather than assuming an action will not affect a tribe.

2. Promote Incentives for Endangered Species Act Conservation. Tribes generally have the perception that they are unjustly penalized for not engaging in large scale land and resource development on their lands and as a result, tribal lands often maintain pristine habitats that support a variety of endangered species. Consequently, tribes are often faced with designation of critical habitat on tribal land, and are required to prepare ESA management plans or otherwise justify exclusion from critical habitat designation. Therefore, the presence of endangered species on tribal lands is often considered as a liability, a view also commonly held by non-Indian governments as well as private landowners. Tribes reject the notion that management of their lands should be dictated by and revolve around Federal directives for endangered species management, instead of fulfilling tribal needs and desires. Short of exempting tribes from the ESA, incentives and alternatives need to be provided to tribes that will allow them to continue managing tribal lands and resources in accordance with their own goals and objectives. An example of this would be the development of an Ecosystem Management Plan that addresses a holistic approach rather than a species-specific approach.

3. Protect Tribal Water Rights. The protection of endangered species should not diminish the importance of water to pueblos/tribes in maintaining their traditional and cultural

values and their economic livelihood for future generations. Where a species is affected by a Federal water project, the courts have held that the projects must be operated consistent with the protection of senior Indian water rights. Any discussion of water resources and any development of recovery plans that dictate or even imply a change in water use should be conducted on a government-to-government basis with each affected pueblo/tribe, taking into full account vested tribal water rights and water resources. Specifically, when developing an environmental baseline by which to gauge the status or trends in a species' population, tribal water rights must be factored in regardless of whether those already vested water rights have been fully exercised. Before Indian water rights are affected, junior users should bear the brunt of restrictions. However, given the lengthy and complicated nature of water rights negotiations or adjudication, parties should not let unresolved water rights issues hold up conservation measures.

4. Seek Other Conservation Options in Lieu of Critical Habitat Designation on Tribal Lands. There is a consensus among most Indian tribes that opposes critical habitat designation on their lands. The arguments against designation include infringement of Federal government policies and regulations on tribal sovereignty, disregard of tribal authority to manage their natural resources in accordance with their goals and objectives, disregard of the potential economic impacts that are placed on tribes, direct conflict between ESA and tribal resource management goals, the lack of Federal funding to conserve endangered species, and finally, the question of whether or not the ESA applies to tribal lands.

   Developing cooperative or conservation agreements between tribal governments and the Service that specifically address endangered species conservation on tribal lands could serve as a mechanism to establish partnerships that would enhance the survival of listed species, while providing tribes the flexibility and option to determine the extent of their involvement in ESA conservation. These agreements could detail commitments tribes are willing to make to protect and manage listed species and could also detail commitments the Service would make to assist tribes in addressing the ESA on tribal lands. Formal agreements may not be necessary when tribal actions already meet mutually beneficial goals. The Service should, whenever possible, defer to existing natural resource conservation management underway by tribes.

   Prior to considering any lands for critical habitat, the Service should inform tribal governments of their intent to designate and should initiate the process in a manner that will ensure that tribes have all necessary information to provide meaningful input. Tribal input should include formal government-to-government consultation with tribal leadership, as well as meetings with their technical representatives. Discussions should include alternatives tribes can consider to avoid designation, and also ways that the Service can directly or indirectly assist in fulfilling tribal desires.

5. Establish Funding Sources. Developing and maintaining endangered species conservation programs require not only a long-term commitment on the part of the management agency, but also a considerable commitment of resources. Lack of adequate funding is frequently a major reason why tribes are reluctant to engage in endangered

species conservation. A considerable burden is often placed on tribal resources because of the need to comply with ESA issues that either directly or indirectly affect them. Tribal resources are expended when tribes are forced to seek exemptions from critical habitat designation, are required to conduct endangered species surveys in order to perform projects, or must participate in ESA-related meetings, programs, and initiatives. Indian tribes have limited funding sources or funding opportunities for endangered species. Although the recovery and conservation of endangered species is a Federal responsibility and mandate, the burden of implementing conservation measures is all too often placed on Indian tribes.

Funding sources to assist tribes in addressing ESA conservation efforts on tribal lands should be established, such as expansion of the Service's Partners for Fish and Wildlife Program or the Middle Rio Grande Endangered Species Collaborative Program to specifically address ESA conservation on tribal lands. The Interior Department should consider the identification of ESA funds to be transferred to the Bureau of Indian Affairs for tribes/pueblos to be utilized through the PL 93-638 process. Any proposed amendments to the ESA should include provisions for the use of Federal funds for recovery or species management by tribes/pueblos under section 6 of the ESA.

6. Implement Secretarial Order 3206. This directive has been extremely positive and defines the tribal/Federal relationship over endangered and sensitive species, and should be upheld and utilized as a mechanism for open dialogue between Federal agencies and tribal governments. This directive also recognizes that Indian tribes are the appropriate governmental entities to manage their lands and tribal trust resources.

   Specifically, in regards to recovery, Secretarial Order 3206 directs Interior Departments to:

   a. Solicit and utilize the expertise of affected Indian tribes by having tribal representation, as appropriate, on recovery teams when the species occurs on Indian lands (including tribally-owned fee lands), affects tribal trust resources, or affects the exercise of tribal rights.
   b. In recognition of tribal rights, cooperate with affected tribes to develop and implement recovery plans in a manner that minimizes the social, cultural and economic impacts on tribal communities, consistent with the timely recovery of listed species. The Service shall be cognizant of tribal desires to attain population levels and conditions that are sufficient to support the meaningful exercise of reserved rights and the protection of tribal management or development prerogatives for Indian resources.
   c. Invite affected Indian tribes, or their designated representatives, to participate in the recovery plan implementation process through the development of a participation plan and through tribally designated membership on recovery teams. The Service shall work cooperatively with affected Indian tribes to identify and implement the most effective measures to speed the recovery process.
   d. Solicit and utilize the expertise of affected Indian tribes in the design of monitoring programs for listed species and for species that have been removed

from the lists of endangered and threatened wildlife and plants occurring on Indian lands or affecting the exercise of tribal rights or tribal trust resources.

7. Respect Cultural Values. Many tribal religious, social, and cultural beliefs are based on the concept of reverence for the earth and all its creatures. In addition, all Native American cultures utilize wildlife and wildlife parts in practicing their traditional and cultural ways. Because certain wildlife species are federally protected, issues can potentially arise that are extremely sensitive. In order to promote and maintain effective communications and working relations with the tribes, Federal and State agencies must be continually sensitive to these values. Care and tact must be used in discussing issues that relate to cultural and traditional practices.

8. Promote Multiple-Use Land Management. Caring for and protecting the environment is paramount to tribal land managers. In promoting this philosophy, tribes generally desire to control the use of their own land, while practicing multiple-use resource management. Woven into the culture are activities such as hunting, fishing, ranching, and farming, which are just as much a part of the value system and way of life as is environmental protection. As stated earlier, many tribes feel that they are affected disproportionately by laws such as the ESA, especially when extensive development on non-Indian lands occurs, leaving tribal lands as refuges for endangered species and consequently preventing tribes from engaging in economic developments on their homelands.

9. Ensure Confidentiality of Tribal Information. All tribes have serious concerns regarding endangered species information that is gathered on tribal land and has consequently inhibited effective cooperative relations with other management agencies. Tribes need to be assured that information collected on tribal lands during the course of research, inventories, and other management activities will not be subject to disclosure to the general public. The tribe must hold discretion over who has access to tribal data and other relevant information. This is especially the case when information has cultural and traditional significance. The confidentiality of information is an important cornerstone of tribal sovereignty, self-governance, and spiritual and religious power. Unfortunately, recent court decisions have undermined the tribes' ability and desire to maintain sensitivity over certain information collected through cooperative efforts, especially when tribes utilize Federal funding to collect information.

1.10.4.2 Specific Recommendations for Implementing Rio Grande Silvery Minnow Recovery on Tribal Lands

While the above recommendations address the implementation of the ESA on tribal lands in general, several specific recommendations for implementing Rio Grande silvery minnow recovery are provided below.

1. A tribal liaison should be a voting member of the Rio Grande silvery minnow technical team. While the technical team currently represents some of the most knowledgeable fisheries biologists in the field, tribal resource managers can provide a perspective that could assist in the recovery efforts. Because tribal lands are strategically located within areas potentially occupied by Rio Grande silvery minnows, habitat conditions on tribal

land could provide potential benefits to the minnow. Tribal resource managers can therefore provide invaluable technical insight based on practical knowledge that could have positive implications to other areas of the minnow's range. Having a tribal representative who is able to articulate tribal interests can alleviate some of the concerns and discomfort tribes have in dealing with the Service. Establishing tribal sub-teams as part of recovery efforts can also serve as a mechanism to encourage more meaningful tribal participation and input.

2. Opportunities should be made available to tribal resource managers, through State, Federal, and private entities, to obtain technical training to collect biological information on tribal lands. Training should include, but not be limited to, the use of appropriate sampling techniques and inventory protocols. In situations where tribal programs may not have adequate technical staff, agencies or other entities engaged in data collection activities should be encouraged to provide assistance to tribes to gather scientific data specific to the Rio Grande silvery minnow for management purposes. Many tribal resource management programs generally lack proper equipment to conduct field data collections. To assist tribes in accomplishing information gathering, functional surplus equipment should be made available to tribes, and/or opportunities provided to tribal resource programs to have access to agency equipment by means of loans or the purchase of equipment specifically for tribal use.

3. Because of the sensitivity of tribal data, information collected on tribal lands should remain in the possession of tribes. Divulging or sharing of tribal information must be at their discretion. Tribes will determine the nature of information and the accessibility restrictions on tribal sensitive data. It is vital that agencies or individuals who are permitted to access tribal data have a clear understanding that regardless of whether the information is general or specific, it must be considered confidential and distributed or shared appropriately only upon written permission from the tribe. Tribes who engage in Rio Grande silvery minnow habitat or population data collection are encouraged to be proactive in managing their resources; in accomplishing this, it could be beneficial for tribes to share some information with other management agencies. One way of sharing data could be through the establishment of technical work groups, consisting of tribal and agency biologists. Such a workgroup could, at the request of the tribes, assist in data collection as well as other Rio Grande silvery minnow conservation activities. The extent of cooperation could be defined by means of written agreements, which must also contain information confidentiality protocols.

4. If a tribe has a Rio Grande silvery minnow recovery plan or is thinking about developing one, it should strongly consider implementing a tribal resource management plan reviewed by the Service in compliance with section 7 of the ESA.

5. Funding sources must be made available to tribes to assist them in conducting habitat and population assessments on tribal land. If tribes have the technical capability, they should be encouraged to carry out all assessments on tribal lands. If a tribe does not have the in-house technical expertise necessary to conduct the fieldwork, funding should be made

available to the tribes to develop technical capacity or to have the option to hire appropriate expertise.

6. Several pueblos in the middle Rio Grande have developed Rio Grande silvery minnow management plans. These plans identify activities the tribes will engage in to assist in the conservation and management of minnows and minnow habitat. These management plans, which have been reviewed and accepted by the Service, were developed to promote a proactive approach to the ESA and to preclude the need for designation of critical habitat on tribal lands. Because each pueblo is unique, each management plan is likewise unique in its approach to Rio Grande silvery minnow management. Tribes have demonstrated that they are fully capable of managing their own natural resources. Tribes therefore have a vested interest and desire to contribute to Rio Grande silvery minnow recovery, while also promoting tribal self-sufficiency and maintaining their sovereign status. How effective these plans are in the conservation of the Rio Grande silvery minnow depends on the availability of funding for implementation.

7. Recovery efforts for the Rio Grande silvery minnow may include population augmentation and possibly the establishment of experimental populations. Consequently, it is highly likely that pueblos that have lands along the mainstem of the Rio Grande will be directly affected by these recovery actions. It is imperative that each tribe be consulted on a government-to-government basis (i.e., Secretarial Order 3206 and Presidential Memorandum of April 29, 1994). Each affected tribe may, at its discretion, allow access to tribal lands followed by Rio Grande silvery minnow releases. Although it is the prerogative of each tribe to either participate or not participate in Rio Grande silvery minnow augmentation or establishment of experimental populations, it is of paramount importance that the Service clearly explain and discuss with all tribes the processes involved as well as the potential implications that could result from these actions, prior to the Service making any decisions or taking any action that might possibly impact tribal rights and resources.

8. Suggestions for region-wide water conservation should be included in the recovery plan. Protection of endangered species does not always automatically mean a total abandonment of all forms of development or severe impacts to tribal and non-tribal water rights. If species can be protected through conservation measures, this is always preferable to other alternatives and there may be relatively little change in the way sustainable development is carried out. In the case of the Rio Grande silvery minnow, water conservation may play a significant role in assuring that tribes continue to use water to their advantage while still offering a means of protection to listed species. The Service should always strive to ensure that implementation of any Rio Grande silvery minnow conservation measures not result in an adverse impact to a tribe's exercise of it aboriginal, Prior and Paramount, or federally reserved water rights.

9. It is the prerogative of each individual tribe to participate in the recovery process. Any tribe involved in the recovery process has the option of sharing information related to the Rio Grande silvery minnow recovery process.

It is believed the recommendations provided above will help to alleviate some tribal concerns, and will allow tribes to more effectively participate and contribute positively to the conservation and preservation of ecosystems. Considering the positive atmosphere that is presently emerging within the Service and the desire among many tribal leaders and resource managers to be proactive in the management of tribal resources, it is important that this opportunity be cultivated into a cooperative partnership that will continue fostering sound natural resources conservation and a healthy environment, while strengthening the sovereignty and self-sufficiency of tribal governments.

2.0 RECOVERY STRATEGY

As described in the previous section, the Rio Grande silvery minnow's range and abundance have become severely limited due to a number of factors. Primary among these are habitat degradation (extensive channel drying, disruption of the natural hydrograph by water control structures, and changes in stream morphology) and habitat fragmentation (division of the habitat into discrete sections by water control structures).

This section and those that follow it (Sections 2.0, 3.0, 4.0, and 5.0) describe the recovery plan for the Rio Grande silvery minnow, as developed by the Rio Grande Silvery Minnow Recovery Team. Included are:

- an overall strategy (below);
- the goals of the plan (prevention of extinction, downlisting, and eventual delisting), the objectives that must be achieved to meet those goals, and the criteria by which the objectives will be measured (Section 3.0);
- the management actions that will lead to recovery of the species (Section 4.0);
- an explicit description of how the recovery plan addresses the threats to the species (Section 5.0); and
- an implementation schedule, including time estimates, responsible parties, and estimated costs (Section 6.0).

This Rio Grande Silvery Minnow Recovery Plan takes a three-pronged approach: 1) implement immediate steps (actions) that are needed to prevent the extinction of the species; 2) implement steps that will allow downlisting of the species from endangered to threatened; and 3) implement steps that will allow the eventual removal of the species from the List of Endangered and Threatened Wildlife (delisting). The steps within these approaches are not necessarily distinct from one another. In most cases, for example, actions taken immediately will contribute to the conditions that will eventually allow for delisting.

All of the actions outlined in Section 4.0 are necessary for the recovery of the Rio Grande silvery minnow. The most important and overarching actions are below.

1. Develop additional, detailed knowledge of the biology of the species and the habitat upon which it depends. This information is crucial to implementing other actions in the program.

2. Restore and protect the habitats used by the species, and protect and expand the existing populations, by means of the following:
   - strategic habitat modifications to provide proper habitat at low flows;
   - new strategies to provide water needed by the species;
   - habitat restoration activities; and
   - a comprehensive program of propagation and augmentation (including establishing at least two new populations);

3. Follow an adaptive management approach throughout the recovery process, to ensure that research and management actions are implemented in a timely manner and adjusted as necessary.

4. Implement monitoring efforts throughout the recovery process, to track progress toward recovery and through delisting and post-delisting.

5. Implement public awareness and education programs to ensure that all interested parties are informed of the need for and rationale for recovery actions, to enlist their support for the program.

In addition to the strategy outlined above, the Rio Grande Silvery Minnow Recovery Team recognizes the need for long-term management of the habitat and the species once delisting is accomplished.

3.0 RECOVERY GOALS, OBJECTIVES, AND CRITERIA

The Rio Grande Silvery Minnow Recovery Team has developed a set of detailed recovery goals, objectives, and criteria for the Rio Grande silvery minnow. The *recovery goals* reflect the desired outcome of this plan – prevention of extinction, downlisting the species, and delisting the species. The *recovery objectives* describe the conditions that are necessary to achieve those goals. The *recovery criteria* describe the desired values for those conditions, and have been established for each recovery objective.

The primary intent of the Endangered Species Act (ESA) is to recover listed species, and the ecosystems on which they depend, such that the protections of the ESA are no longer necessary. Recovery criteria are those objective, measurable criteria that if met, provide a basis for determining whether a species can be considered for downlisting (reclassification to threatened status) or delisting (removal from the list of threatened and endangered species). In the following, downlisting and delisting criteria are divided into two sets: those that meet demographic goals, and those that address the alleviation of threats. We view the demographic criteria as overarching. The achievement of demographic goals, by definition, means that threats have been reduced sufficiently to change the species' status from endangered to threatened, and, subsequently, to remove it from the endangered species list. However, threats-based criteria specifically address the characteristics that led to the species decline and need for listing under the ESA. Threats are described in detail in Section 1.7.4 of this plan. They are categorized under the five listing factors of the ESA:

- Factor A. The present or threatened destruction, modification, or curtailment of its habitat or range.
- Factor B. Overutilization for commercial, recreational, scientific, or educational purposes.
- Factor C. Disease or predation.
- Factor D. The inadequacy of existing regulatory mechanisms.
- Factor E. Other natural or manmade factors affecting its continued existence.

Recovery Goal 1. Prevent the extinction of the Rio Grande silvery minnow in the middle Rio Grande of New Mexico.

Recovery Objective 1-A. A middle Rio Grande population at a level sufficient to prevent extinction as defined by criteria related to distribution and reproduction, measured through annual monitoring of the population.

Recovery Criterion 1-A-1. Using the standard sampling protocol (Appendix E), and sampling at a minimum of 20 sites distributed throughout the middle Rio Grande in New Mexico, document the presence of Rio Grande silvery minnow (all unmarked fish) at ¾ of all sites, per reach, sampled during October.

Habitat fragmentation has subdivided the extant population into three distinct sub-reaches, and diversions limit genetic exchange to the downstream direction. The presence of silvery

minnow in all three reaches demonstrates reasonable certainty that the remaining genetic makeup of the species has been preserved and that the population can withstand a catastrophic event in any one reach.

Recovery Criterion 1-A-2. Annual reproduction in the middle Rio Grande below Cochiti Reservoir, as indicated by the presence of young-of-year at ¾ of all sites, per reach, sampled during October.

Recovery Objective 1-B. A captive population sufficient to prevent extinction.

Recovery Criterion 1-B-1. A captive population of 50,000 to 100,000 fish with a composition and distribution (among facilities) consistent with the recommendations of the Rio Grande Silvery Minnow Genetics Management and Propagation Plan (U.S. Fish and Wildlife Service 2007).

Recovery Goal 2. Recover the Rio Grande silvery minnow to an extent sufficient to change its status on the List of Endangered and Threatened Wildlife from endangered to threatened (downlisting).

Demographic Criteria:

Recovery Objective 2-A. Three populations, including a stable middle Rio Grande population and at least two additional populations that are self-sustaining (see box p. 3), in the Rio Grande silvery minnow's historical range, as defined by criteria related to population distribution, annual reproduction and extinction risk.

For the purposes of this document, a *self-sustaining population* is defined as one that can sustain a specified population level without augmentation with captive-bred fish. A *managed population* is one that requires some augmentation to sustain specified population number.

Recovery Criterion 2-A-1. Using the standard sampling protocol (Appendix E), and sampling at a minimum of 20 sites distributed throughout the middle Rio Grande in New Mexico, document for at least 5 consecutive years, an October catch per unit effort (CPUE) from all monitoring sites within each reach of > 5 fish/100 m^2.

Recovery Criterion 2-A-2. Annual reproduction in the middle Rio Grande below Cochiti Reservoir, as indicated by the presence of young-of-year from ¾ of the monitoring sites, per reach, for at least five consecutive years.

Recovery Criterion 2-A-3. Two additional populations of Rio Grande silvery minnow, in the historical range of the species but outside the middle Rio Grande of New Mexico, that each demonstrate (by quantitative analysis) a probability of extinction in the wild of less than 10% within 50 years.

For example, the preliminary PVA developed for the Big Bend reintroduction project suggests that a population that exhibits a long-term lambda of 1.025 will have a lower than

10% probability of going extinct in 50 years. These results assume 5 years of stocking at least 200,000 individuals per year. These values will likely change, as estimates of available habitat are refined and restoration activities modify the area's carrying capacity.

Threats-based Criteria:

Recovery Objective 2-B. Habitat sufficient to support three such populations, as defined by criteria related to river base flow, hydrographs, and habitat and water quality (Factors A, C, D, and E).

Recovery Criterion 2-B-1. Base flow within occupied habitat sufficient to generate survival rates necessary to achieve Criteria 2-A-1. Wetted habitat represents the overall carrying capacity of a particular area for Rio Grande silvery minnow and influences survival rates for the population. The amount and distribution of base flows necessary for recovery can be informed by a PVA.

Recovery Criterion 2-B-2. Recruitment flows that generate population growth rates necessary to achieve Criteria 2-A-1.

Recovery Criterion 2-B-3. Habitat of sufficient quantity and quality to generate recruitment and survival rates that meet Criteria 2-A-1. Quantity and quality will vary by site but each location is likely to need increased nursery habitat and overall channel complexity. These increases can be achieved through restoration, flow management, and removing impediments to river migration, such as giant cane in the Big Bend area.

Recovery Criterion 2-B-4. Improve water quality within occupied areas and reintroduction sites to support recruitment and survival rates necessary to achieve Criteria 2-A-1.

Recovery Goal 3. Recover the Rio Grande silvery minnow to an extent sufficient to remove it from the List of Endangered and Threatened Wildlife (delisting).

Demographic Criteria:

Recovery Objective 3-A. Three self-sustaining populations within the Rio Grande silvery minnow's historical range, as defined by criteria related to population size, distribution and extinction risk.

Recovery Criterion 3-A-1. Three populations of Rio Grande silvery minnow, in the historical range of the species, each of which demonstrate (using quantitative analysis) a probability of extinction in the wild of less than 10% within 100 years.

Threats-based Criteria:

Recovery Objective 3-B. Habitat sufficient to support three such populations, as defined by criteria related to river base flow, hydrographs, and habitat and water quality (Factors A, C, D, and E).

Recovery Criterion 3-B-1. Base flows within occupied habitat sufficient to generate survival rates necessary to achieve Criteria 3-A-1.

Recovery Criterion 3-B-2. Recruitment flows that generate population growth rates necessary to achieve Criteria 3-A-1.

Recovery Criterion 3-B-3. Habitat of sufficient quantity and quality to generate recruitment and survival rates that meet Criteria 3-A-1.

Recovery Criterion 3-B-4. Water quality within occupied areas and reintroduction sites to support survival rates of Rio Grande silvery minnow necessary to achieve Criteria 3-A-1.

4.0 RECOVERY PROGRAM

4.1 Introduction

This section describes the actions that, if implemented, will result in achieving the goals of the Rio Grande Silvery Minnow Recovery Plan. The actions are presented first with narrative descriptions, and then are presented in outline form (Section 5.0, Table 2). Some of these efforts are already underway.

This program will be evaluated, and updated if necessary, at the end of each five-year period. The recovery team will also review the progress made on these actions at least annually.

Although completion of all the recommended actions is expected to result in recovery of the Rio Grande silvery minnow, recovery is not dependent upon completion of every activity described here.

Of particular importance will be complete and regular coordination with tribes and pueblos throughout the recovery process. Tribal waters comprise a significant portion of the silvery minnow's current habitat and are paramount to ensuring the survival of the species. Tribal participation in the recovery process is voluntary. Technical and financial assistance should be made available to all tribes and pueblos who elect to implement recovery actions on their lands.

The number format used to describe these actions does not indicate the relative priority or chronological sequence of the recovery actions. Each individual recovery action is assigned a priority level, a cost estimate, and responsible party; that information is presented in Section 6.0, Implementation Schedule. A cross-reference chart detailing how the recovery actions relate to the five listing factors, the specific threats to the species, and the recovery objectives and criteria, is provided in Section 5.0, Addressing Threats.

4.2 Recovery Actions and Narrative

1.0 Develop a thorough knowledge of the Rio Grande silvery minnow's life history, ecology, and behavior, and the current status of its habitat.

Perpetuation of the Rio Grande silvery minnow in the wild depends upon a thorough knowledge of the species' life history, ecology, and behavior, and application of that knowledge to restore and protect appropriate habitats.

1.1 Investigate and determine biological factors.

While much has been learned about the Rio Grande silvery minnow's life history, there are still crucial gaps in our knowledge. The actions below address some of those gaps.

1.1.1 Improve understanding of the relationship between environmental factors and spawning by the Rio Grande silvery minnow.

More information is needed on what factors trigger spawning (e.g., increases in flow, water temperature, and chemical composition of water). While Rio Grande silvery minnow are known to spawn with increases in streamflow, it is not known how the

precise timing or magnitude of spawning is affected by various flow scenarios. These factors should be analyzed individually so that the most important cues can be identified.

1.1.2 Determine distances and rates of dispersal for various life stages of Rio Grande silvery minnow.

Factors that need to be investigated and documented include:

- Rates of travel and magnitude of dispersal of eggs and larvae at various flows.
- Movement of young-of-year and juveniles from inundated floodplain habitat to the main channel at various flow regimes.
- Upstream and downstream movement/dispersal of adults during various flow regimens, including distances moved, quantification of number of fish moving, and seasonality of movement.

1.1.3 Improve understanding of the ecological conditions that influence survival in different life stages of Rio Grande silvery minnow.

Developmental progression of Rio Grande silvery minnow from larvae to juvenile and juvenile to adult fish (i.e. recruitment) depends on numerous biotic and abiotic conditions. Recruitment rates between even these broad ontogenetic (developmental) stages (larvae, juvenile, adult) are not currently known for Rio Grande silvery minnow and correspond to different ecological conditions. For example, while spring flows are known to influence egg and larval survival, the conditions that most influence juvenile and adult survival are not fully understood. A thorough understanding of the ecological correlates for survival at different life stages would help determine the management actions necessary to achieve recovery.

1.1.4. Develop relationships between age and length in silvery minnow.

A study should be conducted to develop age-length relationships for the silvery minnow to improve age estimates for larger fish. At least two independently verified aging techniques (such as scales and otoliths) should be utilized.

1.2 Investigate and improve understanding of habitat requirements.

The actions below will help to fill in gaps in our knowledge of the habitat needs of the Rio Grande silvery minnow, as well as help to determine areas where the species can be reintroduced in the future.

1.2.1 Improve understanding of habitats occupied by early life stages of Rio Grande silvery minnow.

Dudley and Platania (1997) studied habitat use and availability of post-larval (>20 mm SL) Rio Grande silvery minnow. The habitat requirements of earlier life stages ($\leq$20 mm SL) of Rio Grande silvery minnow need to be better understood in order to effectively manage populations.

1.2.2 Improve understanding of stream flows that provide suitable habitat for all life stages of Rio Grande silvery minnow.

An improved understanding of the relationship between stream flow and habitat availability will help determine the amount, location, and duration of flows necessary to provide suitable habitat for the various life stages of the Rio Grande silvery minnow.

1.2.3 Develop strategic habitat restoration plans for the Rio Grande silvery minnow in the middle Rio Grande and elsewhere in its historical range.

A strategic program will assist agencies in determining where to initiate habitat construction projects essential to preventing population decline or extinction. Habitat plans should identify the extent of existing habitat within occupied reaches and reintroduction areas. Habitat features that create flooded surfaces during the Rio Grande silvery minnow spawning period should be emphasized.

Comprehensive plans should include an analysis of:

- The extent of the floodplain, using geographic information systems and Digital Elevation models. Ground surveys and aerial photography can estimate the degree of channel incision and the flow needed to flood terraces for creating Rio Grande silvery minnow habitat. Pointbars and islands may provide some essential floodplain habitat at some flows.

- Trends of channel degradation and aggradation. River channel aggradation and degradation data define long-term trends for channel incision and floodplain abandonment. These studies can provide insights on riverine and Rio Grande silvery minnow habitat quality.

- Site specific recommendations for restoration techniques and designs. Evaluation criteria for such designs should include costs, environmental disturbance, longevity, ease of construction, and habitat suitability over a range of flows.

Reach specific plans have been developed for portions of the middle Rio Grande River. There are numerous reports by action agencies and the MRGESCP that can provide guidance for habitat restoration

In addition, a program of non-native floodplain plant removal and native floodplain plant replacement is needed, with a bi-national approach where appropriate.

1.2.4 Develop a habitat restoration monitoring program that evaluates the efficacy of habitat restoration techniques.

Comprehensive and systematic sampling for silvery minnows should be conducted at multiple restored and unrestored sites under similar environmental conditions (time of year, flow, temperature) to determine the effectiveness of restoration activities on silvery minnow population dynamics.

1.3 Continue genetic studies on Rio Grande silvery minnow populations.

The ability of a species to persist over the long term is determined in part by the amount of genetic variation that is retained by a species. Baseline studies of Rio Grande silvery minnow genetic variation suggest there have been recent sharp declines in N_e and mitochondrial haplotype diversity in wild populations. Monitoring of Rio Grande silvery minnow genetic diversity is necessary to determine whether these declines are continuing and to evaluate the effectiveness of measures taken to maintain genetic diversity

1.4 Improve understanding of the nature, extent, and role of water quality degradation in the decline of the Rio Grande silvery minnow, as well as the water quality standards necessary for its protection and recovery.

Many land use activities and their resultant discharges (both point and non-point) have the potential to affect the Rio Grande silvery minnow and its habitat. These include discharges from industrial sites, wastewater treatment plants, flood channels, and mining sites, runoff from feedlots and grazing land, return flows from agriculture, and other sources. The impacts of these activities and their discharges are not well understood and should be investigated.

1.4.1 Continue to collect and evaluate existing water and sediment quality data and identify future investigations that are needed.

The recovery team has worked to identify areas of the Rio Grande that have impairments in water quality and sediment quality that may correlate to the absence or low abundance of the Rio Grande silvery minnow. No conclusions have been reached and additional work needs to be done. Data collection and monitoring efforts should be coordinated with ongoing studies, including those conducted under MRGESCP (http://www.fws.gov/mrgesacp/pdf/Hydrologic_and_Biologic_Data.pdf), the U.S. Geological Survey's Rio Grande Valley National Water-Quality Assessment Program, and the investigation of Rio Grande water quality by the U.S. and Mexico.

Many types of pollutants have the potential to affect the aquatic ecosystem and the Rio Grande silvery minnow, and should be considered for further evaluation. Recommendations for additional water quality data collection should be formulated, and all data should be included in the adaptive management database.

1.4.2 Design and undertake toxicity tests to assess the effects of contaminants on various life stages of Rio Grande silvery minnow.

Tests need to be conducted in order to determine if the concentrations of several common inorganic contaminants found in the middle Rio Grande affect the survival of the Rio Grande silvery minnow. Further, research should assess the suitability of the fathead minnow as a surrogate for Rio Grande silvery minnow.

Testing of organic chemicals such as pharmaceuticals may also be warranted. In 2001, sampling in the middle Rio Grande found up to 140 nanograms per liter of estrone in ambient water below a wastewater treatment plant discharge. The potential endocrine-disrupting effects of such chemicals should be assessed.

1.4.3 Design and undertake studies to assess the effects of point and non-point source discharges on Rio Grande silvery minnow food sources.
Pollutants have the potential to affect the Rio Grande silvery minnow in indirect as well as direct ways. An assessment of how various pollutants are affecting other species will help to uncover whether or not such pollutants might indirectly be affecting the Rio Grande silvery minnow.

1.4.4 Design and undertake studies to assess the effects of stormwater pulse-flows (water quality and contaminants) on Rio Grande silvery minnow.
There are few industrial effluent discharges to the Rio Grande or to its tributaries in New Mexico; point source discharges are largely from municipal wastewater treatment plants (WWTPs). Effluent discharges from WWTPs have been demonstrated to contain contaminants that may affect the water quality of the river. While most treated WWTP effluents are not expected to adversely affect aquatic life when that effluent quality meets the water quality limits specified by the EPA, accidental violations could cause toxic conditions for Rio Grande silvery minnow near points of discharge. The short- and long-term effects of such events on Rio Grande silvery minnows should be evaluated.

1.4.5 Design and undertake studies to determine the effects of various flow regimes and pollutant loading on water quality in Rio Grande silvery minnow habitat.
There is little information available on the correlation between water quantity and quality of suitable habitat for the species. Water quality issues specifically associated with extreme low flow conditions, such as temperature, dissolved oxygen, and pH variations, can lower the toxicity thresholds of some parameters. It is important to determine this information for effective management of existing populations as well as for determining the feasibility of reestablishment sites.

1.4.6 Determine turbidity and sediment levels that reflect ecological conditions suitable for the Rio Grande silvery minnow.
Higher turbidity levels have been associated with spawning of Rio Grande silvery minnows. However, dams and other diversions alter the natural sediments and turbidity levels. Sediments and turbidity levels that optimize species recruitment and survival should be determined and the means to obtain these in the Rio Grande explored.

1.4.7 Develop water quality criteria for protection of the Rio Grande silvery minnow.
The development of water quality criteria for the Rio Grande silvery minnow will allow for the adoption of water quality standards. Such standards can be adopted by both States and pueblos under the Clean Water Act Section 106 program.

1.5 Improve understanding of the nature and extent of interaction between other fish species (native and non-native) and Rio Grande silvery minnow, and the role of these species in the decline of Rio Grande silvery minnow.
The introduction and spread of non-native fish species has been identified as a threat to the continued existence of Rio Grande silvery minnow. Non-native species have been introduced in the past to provide additional angling opportunities (e.g., channel catfish

and largemouth bass), as food fishes (e.g., common carp), and as biological controls (western mosquitofish).

Regardless of the reason for introduction, most (perhaps all) non-native fishes in the Rio Grande drainage have at least the potential to interact negatively with Rio Grande silvery minnow. Some may compete for limited resources such as food, nursery habitat, and escape cover, while others may prey upon them or pose a threat through hybridization. The plains minnow, a member of the same taxonomic genus as the Rio Grande silvery minnow, was found in the Pecos River shortly before the extirpation of the Rio Grande silvery minnow from that river was documented. Low-level introgression between the two species was determined from several specimens (Cook et al. 1992), but it is uncertain if hybridization played a role in the Rio Grande silvery minnow's extirpation.

Occurrence, distribution, and abundance of non-native species within the historical range of the Rio Grande silvery minnow vary geographically. At least 16 non-native fishes occur in the middle Rio Grande of New Mexico (Dudley et al. 2003, Plateau Ecosystems Consulting 2001) and 15 have been documented in the historical New Mexico-Pecos River range of the Rio Grande silvery minnow (Sublette et al. 1990). The extent of interaction (from none to competition for limited resources to predation) varies with the non-native species in question, its life stage, and a wide array of biotic and abiotic environmental influences.

1.5.1 Improve understanding of the distribution and extent of non-native fish species.

Extensive sampling of fish assemblages in the Rio Grande and Pecos Rivers since 1990 has added considerably to the knowledge of non-native fish occurrence and abundance in much of historical range of the Rio Grande silvery minnow. Using the data in these studies, the distribution, abundance, and habitat associations of all regularly occurring non-native fish species in the Rio Grande drainage should be compiled into a single document and assessments of non-native "problems" within each reach made. Also needed are studies to quantify movement of non-native fishes from reservoirs and studies to evaluate mechanical or selective removal of problem non-native fishes.

1.5.2 Improve understanding of predation and competition effects on Rio Grande silvery minnow by other Rio Grande fish species.

There have been no studies to determine if non-native piscivores (animals feeding on fish such as channel catfish) prey upon or compete with Rio Grande silvery minnow. In the Rio Grande, most extant non-native species are more likely predators than competitors, but in the Pecos River, several extant non-native cyprinids (e.g., plains minnow and Arkansas River shiner) might compete with Rio Grande silvery minnow if it was repatriated to that system. Studies to characterize the mesohabitats of the Rio Grande silvery minnow and associated species are ongoing. The results of these studies will provide a measure of the likelihood of negative interactions between individual non-native species and the Rio Grande silvery minnow in the Rio Grande. Based upon this work, more detailed studies may be warranted. Such studies should focus on characterizing specific modes of interaction, quantification of impacts, and identification

of means or methods to ameliorate negative interactions. Data obtained from Rio Grande silvery minnow habitat association studies in the Rio Grande will be useful in evaluating the efficacy of restoring Rio Grande silvery minnow to its historical Pecos River range.

1.5.3 Improve understanding of the effects of different flow regimes (timing, magnitude, amplitude, duration) on non-native fishes.

Ongoing studies, while focused on characterizing habitat use by the Rio Grande silvery minnow under a variety of flows, are also acquiring information that could be used to characterize relationships between flow regimes and individual non-native fish species. Rather than considering non-native fishes collectively, studies (using information acquired under aforementioned studies) should focus on those non-native species that have been demonstrated to have negative interactions with Rio Grande silvery minnow. Based upon this work, additional research and experimentation may be warranted.

1.5.4 Review and update existing regulations and policies on stocking of non-native sport fishes and bait fish use.

The NMDGF does not stock warmwater sport fishes in the middle Rio Grande. Non-native salmonids, however, are stocked seasonally in major drains and canals of the Middle Rio Grande Conservancy District upstream of Isleta. Under the ESA, NMDGF is required to evaluate the effects of sport fish stocking in drains to ensure doing so has no adverse effects on federally-listed species.

Bait fish regulations in the Rio Grande silvery minnow's historical range vary considerably. The State of Texas enacted bait fish regulations for the Pecos River region in 1999; the only bait fish allowed are common carp, fathead minnow, gizzard and threadfin shad, golden shiner, goldfish, Mexican tetra, Rio Grande cichlid, silversides, and sunfish. In the New Mexico portion of the Pecos River, bait fish sale and use is restricted to native fishes (red shiner and fathead minnow). In addition, anglers may not personally obtain bait fish from the Pecos River within the reach designated as critical habitat for Pecos bluntnose shiner. In the New Mexico portion of the Rio Grande, bait fish regulations are less restrictive.

Bait fish regulations should be updated to reflect the following: 1) all purveyors of bait fish in the Rio Grande watershed within New Mexico and Texas should be licensed and inspected at least annually; 2) only species native to the Rio Grande should be legal bait fish; 3) all bait fish imported into the watershed should be certified disease-free; 4) bait fish should be purchased only from licensed and inspected dealers; and 5) it should be illegal to obtain bait fish, by seining or traps, from the Rio Grande within the reach currently occupied by the Rio Grande silvery minnow.

1.6 Investigate competitive interactions between congeners at various life stages.

The Pecos River has been identified as a potential site for reestablishment of Rio Grande silvery minnow. However, a full understanding of the mechanisms responsible for the extirpation of the species must first be achieved. Hybridization between Rio Grande silvery minnow and the plains minnow was hypothesized to be one of the factors responsible for the extirpation of Rio Grande silvery minnow in the Pecos River. Recent

studies have indicated that competition was the more likely cause (Caldwell 2003; Moyer et al. 2005). The ability of plains minnow to invade and become established in the Rio Grande and Pecos Rivers must be assessed. An investigation designed to address competition between Rio Grande silvery minnow and the plains minnow would be useful to predict the outcome of any efforts to reestablish the Rio Grande silvery minnow in the Pecos River.

1.7 Determine the nature and extent of predation on Rio Grande silvery minnow by avian and other predators.

While predation is a natural part of the ecology of the Rio Grande silvery minnow, the importance of this factor is largely unknown. Of special interest is the role that avian and other non-fish predators have on the species, especially during sensitive early periods of its life history and when it inhabits shallow, nearshore habitats.

2.0 Restore, protect, and modify habitats as necessary to alleviate threats to the Rio Grande silvery minnow.

As described earlier in this report, various activities have reduced and altered Rio Grande silvery minnow habitat within the historic range of the species. To ensure survival of the species, it will be necessary to restore and protect habitats, as well as develop and implement water management strategies that maintain suitable habitat.

2.1 Modify habitats as needed.

Comprehensive habitat restoration plans have been or are being developed for each reach of the middle Rio Grande and should be developed for reintroduction sites (see 1.2.4). These plans should be implemented to expand available habitat for the silvery minnow.

2.1.1 Implement habitat restoration projects throughout the middle Rio Grande and the historic range where appropriate.

Several techniques for improving aquatic habitats at a mesohabitat scale are discussed in the Habitat Restoration Plan for the Middle Rio Grande (Tetra Tech 2004). These include terrace and bank lowering, high-flow ephemeral channels, high-flow bank-line embayments, main-channel widening, removal of lateral confinements, river bar and island enhancement, and destabilization of islands and bars. The construction of Rio Grande silvery minnow nursery and refugial habitat would provide areas to support recruitment and enhance survival throughout the year.

In addition, a program of non-native floodplain plant removal in Texas and native floodplain plant replacement is needed, with a bi-national approach where appropriate.

2.1.2 Provide for fish passage at irrigation diversion structures.

Rio Grande silvery minnow eggs and larvae move downstream, potentially stranding fish below barriers (diversion structures). Promoting the ability of Rio Grande silvery minnows to independently disperse between sub-reaches can increase reproduction among sub-populations, thereby increasing effective population size and maximizing the retention of genetic diversity.

The successful design and implementation of fish passage structures (or other diversion facilities that do not block upstream dispersal) could allow Rio Grande silvery minnow to repopulate areas where they were spawned.

2.1.3 Implement management strategies to reduce entrainment of Rio Grande silvery minnow into irrigation canals and the Low Flow Conveyance Channel.
Downstream repopulation of the Rio Grande silvery minnow is enhanced by the free and unimpeded downstream movement of eggs, larvae, and adults within the Rio Grande. Entrainment of Rio Grande silvery minnows into irrigation canals may reduce downstream recruitment. The extent of entrainment should be investigated and quantified under a range of flows and diversion structures modified or managed to minimize entrainment, or provide for an outfall to the river.

2.1.4 Design proposed instream and floodplain projects in a manner that enhances their habitat value for the Rio Grande silvery minnow.
River maintenance projects should be designed to minimize negative impacts to the Rio Grande silvery minnow and its habitat and create habitat where possible.

2.2 Provide suitable habitat for the Rio Grande silvery minnow using water management strategies for the middle Rio Grande.
The following actions are recommended with the understanding that water management in the middle Rio Grande is governed by a variety of State, Federal and interstate laws, contracts, and authorities. Each action must be evaluated in the context of these existing regulatory constraints. Any proposed changes that affect or impact tribal trust resources or water rights require the approval or involvement of the tribes/pueblos.

2.2.1 Identify constraints (climate, depletions and other losses, reservoir operations, diversions) that affect habitat in the middle Rio Grande during periods of low flow.
Determine legal, institutional, and physical requirements for delivering conservation water to support habitat and other biological functions.

2.2.2 Implement changes in river and dam operations (and other options) to enhance habitat for Rio Grande silvery minnow in the middle Rio Grande.
Dams should be operated in a manner that enhances habitat for the Rio Grande silvery minnow, e.g., by providing sufficient storage capacity and by providing necessary flow regimes that mimic natural flow conditions.

2.2.2.1 Retrofit or modify, if necessary, the operation of dams where sediment retention may be effectively managed for partial restoration of historic geomorphology in the middle Rio Grande.
Sediment retention behind dams has resulted in channel incision and degradation of Rio Grande silvery minnow habitat. Partial passage of sediment at selected dams through operations or retrofitting with sediment transport features may be options for managing Rio Grande silvery minnow habitat.

2.2.2.2 Provide storage space for water to augment streamflow in the middle Rio Grande

Modify existing authorities and/or agreements to allow for storage space and the delivery of conservation water to support habitat and biological functions.

2.2.2.3 Identify how water supply and flood control operations affect riverine habitat development and habitat availability in the middle Rio Grande, and seek benefits for Rio Grande silvery minnow.

Determine how habitat diversity could be improved through modified reservoir operations. Habitat conditions may be improved by releasing water to encourage the fluvial processes necessary for a more dynamic river channel, to provide for occasional overbank flooding of the bosque, and to bypass sediment through the reservoirs to feed the sediment-starved reaches.

2.2.2.4 Provide for greater flexibility in water releases and/or storage for spawning and larval survivorship in the middle Rio Grande.

For below-average water years, spring runoff may be insufficient to provide adequate floodplain habitat for Rio Grande silvery minnow production. Strategies for managing the hydrograph to provide short-term peaks in runoff should be identified and implemented.

2.2.3 Encourage conjunctive use of surface water and groundwater in the middle Rio Grande.

Develop a management program that would allow water users to use a higher proportion of surface water in wet years for direct use or for groundwater recharge. Direct diversion of groundwater into the river may provide a source of supplemental water in times of drought.

2.2.4 Implement measures to increase water use efficiencies, water conservation, and forbearance in the middle Rio Grande to maintain river flows.

Continue improving water use efficiencies in the middle Rio Grande. To further alleviate future demands on surface water, water conservation plans must be funded and implemented. Legal and institutional issues associated with "saved" water and the impact of various plans and measures on the hydrology and the environment should be considered.

Consider establishing a voluntary water-use forbearance program, in which participants may leave previously irrigated land fallow or may choose to not irrigate and legally reassign the water to other uses. Participants could opt to forbear for a single season, multiple seasons, or at regular intervals. Water acquired through voluntary forbearance could be stored and subsequently released to benefit the species. Work to remove legal and logistical constraints on storage and delivery options (Oad and King 2005).

2.2.5 Acquire water from willing sellers or lessors for purposes of maintaining flows for silvery minnow in the middle Rio Grande.
Water should be purchased or leased and stored in upstream reservoirs for release when surface flows are insufficient to maintain habitat for the Rio Grande silvery minnow.

2.2.6 Establish policies that limit floodplain development in the middle Rio Grande and educate the public on the need to limit such development.
Floodplain development has a negative influence on Rio Grande silvery minnow habitat and prevents natural processes from occurring. Events such as flooding also have great negative economic impact. Foster public awareness of the multiple uses of the riparian bosque habitats and their importance in conserving the natural plants and animals of the region.

2.3 Develop and implement water management strategies that will provide suitable habitat for the Rio Grande silvery minnow in areas where the species will be reintroduced (outside the middle Rio Grande).
This recovery plan calls for the establishment of two additional populations of Rio Grande silvery minnow, outside of its current range of the middle Rio Grande. Doing so will require the development of water management strategies that ensure suitable habitat for the species. The following actions are recommended with the understanding that water management in these reaches is governed by a variety of international, Federal, State, and interstate laws, contracts, and authorities. Each action must be evaluated in the context of these existing regulatory constraints. Any proposed changes that affect or impact tribal trust resources or water rights require the approval or involvement of the tribes/pueblos.

2.3.1 Work with Mexico to provide water delivery to the Rio Grande/Rio Bravo del Norte (Big Bend region of Texas).
The Rio Grande in the Big Bend region of Texas serves as the border between the U.S. and Mexico. Actions taken in Mexico could affect efforts to establish a population of Rio Grande silvery minnow in this area. Since international agreements have been reached to provide water from the Río Conchos to Texas, efforts need to be maintained so that water is supplied to the Rio Grande silvery minnow habitat in the Big Bend region.

2.3.2 Encourage flows within the Big Bend reach that support Rio Grande silvery minnow populations.
Demands on surface water in both countries will likely continue to increase. Cooperative efforts to conserve water must be encouraged, funded, and implemented. Legal and institutional issues associated with "saved" water and the impact of various plans and measures on the hydrology and the environment should be evaluated.

Specific actions could be implemented binationally in the Big Bend region, such as the removal of exotic riparian vegetation and replacement with native riparian vegetation. This could locally enhance the flows of the Rio Grande and help with the establishment of an introduced population of Rio Grande silvery minnow in this reach.

2.3.3 Evaluate and implement, if appropriate, changes in river and reservoir operations to enhance habitat for Rio Grande silvery minnow in reintroduced areas.
River and reservoir operations should be conducted in a manner that enhances habitat for the Rio Grande silvery minnow, such as by providing sufficient storage capacity and by providing flow regimes that improve ecosystem function.

2.3.3.1 Provide for storage of water to augment streamflow in reintroduced areas.
Provide conservation water storage capacity in upstream reservoirs.

2.3.3.2 Identify how reservoir operations for water conveyance affect riverine habitat development and habitat availability in reintroduced areas.
Determine how habitat diversity could be improved through modified reservoir operations. Habitat conditions may be improved by releasing water to encourage the fluvial processes necessary for a more dynamic river channel, to provide for occasional overbank flooding, and to bypass sediment through the reservoirs to feed the sediment-starved reaches.

2.3.4 Investigate the legal, institutional, and technical feasibility of implementing a program of conjunctive use of surface and groundwater in reintroduced areas.
Determine feasibility of establishing a management program that would allow water users to use a higher proportion of surface water in wet years for direct use or for groundwater recharge. Direct diversion of groundwater into the river may provide a source of supplemental water in times of drought. Statutes may need to be enacted to provide for groundwater recharge and recovery.

2.3.5 Implement measures to increase water use efficiencies and conservation in reintroduced areas.
To alleviate future demands on surface water, water conservation plans must be funded and implemented. Legal and institutional issues associated with "saved" water and the impact of various plans and measures on the hydrology and the environment should be considered.

2.3.6 Implement a comprehensive program of data collection on water supply and use for improvement of water and habitat management in reintroduced areas.
A comprehensive program of monitoring surface diversions and return flows, and groundwater use should be implemented.

2.3.7 Retrofit or change the operation of inflow gates at dams where sediment retention is detrimental to the appropriate geomorphology in reintroduced areas.
Sediment retention behind dams has resulted in channel incision and degradation of Rio Grande silvery minnow habitat. Partial passage of sediment at selected dams through operations or retrofitting with sediment transport features may be options for managing Rio Grande silvery minnow habitat.

2.3.8 Establish policies that limit floodplain development in reintroduced areas and educate the public on the need to limit such development.

Floodplain development has a negative influence on Rio Grande silvery minnow habitat and prevents natural processes from occurring. Events such as flooding also have a great negative economic impact. The public needs to be aware of the multiple uses of the riparian bosque habitats and their importance in conserving the natural plants and animals of the region.

2.3.9 Investigate the potential of habitat construction that, during periods of low flow, will provide suitable habitat for the Rio Grande silvery minnow in reintroduced areas.

Construction of habitat features that create flooded surfaces during the Rio Grande silvery minnow spawning period should provide habitat for rearing young fish and contribute to recruitment.

3.0 Ensure the survival of the Rio Grande silvery minnow in its current habitat and reestablish the species into suitable habitats in its historical range.

3.1 Continue Rio Grande silvery minnow captive propagation activities.

Propagation activities have been underway for several years. These efforts should continue in order to provide Rio Grande silvery minnow for augmentation of the existing population when necessary, and for the reestablishment of two additional populations.

3.1.1 Annually update a controlled propagation plan for long-term Rio Grande silvery minnow propagation activities.

A plan to guide captive propagation of Rio Grande silvery minnow has been developed and being implemented (USFWS 2009). This plan incorporates methods and protocols that ensure maximization of remaining genetic diversity. The plan should be reviewed and updated annually to incorporate new information, to consider research needs, and to ensure annual production necessary to meet augmentation and repatriation goals.

3.1.2 Evaluate and annually refine methods of Rio Grande silvery minnow propagation.

Detailed records of propagation efforts should be maintained. This information should be evaluated and considered to improve methods. Where appropriate, specific research efforts may be undertaken to improve propagation/rearing techniques and used to update the controlled propagation plan.

3.1.3 Continue genetic monitoring and study of propagated Rio Grande silvery minnow.

Large changes in Rio Grande silvery minnow abundance may affect genetic diversity. To guide and refine captive propagation protocols, detailed genetic information on both the wild and the captive populations is necessary. Genetic monitoring should follow a detailed protocol designed to provide critical information in a timely manner.

3.1.4 Continue the use of propagated Rio Grande silvery minnow for scientific research.

Propagated Rio Grande silvery minnow maintained in captivity may be used in studies to restore and protect the species. Some examples are described below.

3.1.4.1 Develop a larval fish key to the middle Rio Grande and for stream segments where reintroductions are likely.

A developmental series of Rio Grande silvery minnow was produced from captive spawning of adults collected from the wild. Adults used to produce the series, together with the resultant eggs and larvae, were deposited in the Museum of Southwestern Biology, Division of Fishes. Growth rates and timing of developmental features of Rio Grande silvery minnow are presented in Platania (1995a, 2000). Identification of larval fish would be aided by providing a larval fish key for the middle Rio Grande in New Mexico with morphometric and meristic information (information based on physical measurements) on the Rio Grande silvery minnow. A larval fish key is being developed for the fishes of the middle Rio Grande by researches from Colorado State University in cooperation with Rio Grande silvery minnow propagation facilities. Also, a larval fish key should be developed for locations planned for reintroduction.

3.1.4.2 Determine the efficacy of various methods for marking Rio Grande silvery minnow (all life stages).

Many of the studies proposed in this plan require the ability to track and identify specific sub-populations of Rio Grande silvery minnow. While several marking methods have been evaluated for marking juvenile and adult Rio Grande silvery minnow, no method has been formally tested for marking larval individuals. Laboratory studies to examine and test different mechanisms of marking larval Rio Grande silvery minnow are needed.

3.1.4.3 Determine the role of environmental parameters in sex determination of Rio Grande silvery minnow.

Temperature has been demonstrated to be a factor responsible for determining sex during embryonic development of several species. If this is true with Rio Grande silvery minnow, there may be a need to reassess some conservation strategies.

3.1.4.4 Determine the rate of development and hatching success under various environmental conditions for Rio Grande silvery minnow.

Previous studies have demonstrated a positive correlation between decreased hatching time and increased water temperatures. Additional studies are needed to investigate rates of development and survival of larval fishes under various environmental regimes.

3.2 Continue Rio Grande silvery minnow augmentation activities.

Augmentation of the existing population of the Rio Grande silvery minnow has already taken place. The captive breeding program must be continued in order to provide fish for future augmentation, as necessary.

3.2.1 Annually review and revise the Rio Grande silvery minnow augmentation plan for the middle Rio Grande.

The need for augmentation of populations and sub-populations will spatially and temporally vary. In 2001, the Rio Grande silvery minnow augmentation plan was created (Remshardt 2001). This plan identifies augmentation locations and identifies population number goals is needed to achieve goals in a timely manner. The plan was revised in 2008 (Remshardt 2008b), and should continue to be refined, as new information becomes available and the species moves toward recovery. The plan requires consultation with tribes and pueblos.

3.2.2 Coordinate augmentation needs with propagation activities.

Based upon population estimates, determine the number of Rio Grande silvery minnow needed to augment each population (or sub-population) to enable timely achievement of long-term population goals. Based upon estimates of populations and sub-populations, the current middle Rio Grande augmentation plan includes target densities for each site within each reach. Annual population data is used to refine each augmentation plan.

3.2.3 Improve our understanding of the effects of various stocking conditions and release sites on Rio Grande silvery minnow.

An augmentation program (Remshardt and Davenport 2003) has been in place since June 2002. Releases have occurred at several sites and dates throughout all reaches. Monitoring of the augmentation efforts has provided information on effective stocking conditions and release sites. Research efforts should continue.

Preliminary results have verified the importance of low velocity habitat of sufficient depth (> 0.5 m) for release; these habitats provide areas for cover and acclimation to riverine conditions after release.

3.2.4 Determine the effects of hatchery-to-release site transport conditions on stocked Rio Grande silvery minnow.

Effective transport protocols have been developed and are currently in use for all transfers of Rio Grande silvery minnow.

3.3 Reestablish Rio Grande silvery minnow at appropriate locations in its historical range.

3.3.1 Develop a plan for reestablishment of Rio Grande silvery minnow for each reintroduction location.

An Implementation and Monitoring Plan for the current reintroduction effort in Big Bend was included in the Environmental Assessment. This document includes sections which: 1) describe the purposes, implementation schedule, and costs for the specific sites selected for reestablishment; 2) identify the source of fish used for reestablishment; and 3) establish target levels of both fish and habitat necessary for recovery. This plan coordinates with the augmentation plan for the middle Rio Grande (4.2.3.2.1) to ensure

adequate numbers of fish are available to all programs. All future plans should be similar and coordinate with all other plans such that information collected may be compared more equitably between populations.

The process for developing these plans must continue to involve partners such as tribes, States, landowners, and other interested parties. It may be necessary or appropriate to develop a separate augmentation plan that addresses tribal lands and tribal interests. Such a plan should recognize that tribal participation in reintroduction efforts would be voluntary.

3.3.2 Monitor reintroduced populations of Rio Grande silvery minnow.
Use the above sampling program to conduct long-term fish monitoring to assess spatial and temporal changes in age class structure and abundance of reintroduced populations of Rio Grande silvery minnow and other fishes.

3.4 Develop population viability models to assess extinction probabilities for existing and reintroduced populations.
A Population Viability Analysis (PVA) is a model designed to evaluate the relative effects of demographic stochasticity (randomness), environmental variation, and management activities on a population's long-term extinction risk. A PVA model is being developed (Appendix I) for extant and reintroduced populations of the Rio Grande silvery minnow and should be routinely updated to incorporate new information about the species ecology and biology.

4.0 Develop and implement an adaptive management program and ensure that appropriate research and management activities are implemented in a timely manner to achieve recovery of the Rio Grande silvery minnow.

The Rio Grande and its associated aquatic and riparian habitats are complex and dynamic. Currently, there is considerable uncertainty regarding the potential effects of various Rio Grande silvery minnow management actions on the Rio Grande silvery minnow, water users, and the existing infrastructure. As our understanding of these systems increases, it may be necessary to adjust and refine this recovery plan. This is the essence of adaptive management, which may be defined as management in the face of uncertainty, with a focus on reduction of uncertainty over time.

To maintain an adaptive management approach to the recovery of the Rio Grande silvery minnow, it will be necessary for the recovery team and others to continually analyze new and additional information regarding the biological, physical, and chemical conditions of the Rio Grande basin, as described in the systems below.

4.1 Develop and annually review interim workplans to ensure progress toward recovery of the silvery minnow.
Periodically review, evaluate, and revise research and management activities so that and develop interim workplans that identify and describe activities to be conducted by the program in a given year for conservation of the endangered species. As projects are completed or relevant findings verified, new information may identify additional or

alternative research needs or recovery actions that may be needed. Adaptive management will allow for the development of new research and implementation of management activities. As necessary, recovery actions and goals may be refined or revised to reflect new information and understanding.

4.2 Continue long-term Rio Grande silvery minnow monitoring programs through downlisting and post delisting.

4.2.1 Use the middle Rio Grande Long-Term Fish Population Monitoring Program methodology as the model in the development and implementation of a sampling protocol for a long-term fish monitoring program for reintroduced populations.

Monitoring programs for each of the populations should build on existing data and use statistically valid methods to assess changes in age-class structure and abundance of Rio Grande silvery minnows and other fish. The Middle Rio Grande Long-Term Fish Population Monitoring Program (Appendix H) is an established and effective methodology for monitoring the population of the middle Rio Grande and may provide insights to other developing programs.

4.2.2 Develop and implement a sampling methodology of sufficient rigor to generate a statistically reliable population estimate for each population of Rio Grande silvery minnow.

The Rio Grande silvery minnow Population Estimation Program was designed to develop, refine, test, and implement methods that could generate statistically rigorous population estimates for the middle Rio Grande. The final year of three years of fieldwork was initiated in 2008. Refinements should be used as the foundation for future studies (Dudley et al. 2009). Because recovery objectives are tied to population estimates, a reliable method of determining the number of individuals in a population (or sub-population) should continue.

4.2.3 Establish and maintain a single, centralized, standardized database for storage and retrieval of hydrologic, biologic, economic, and social data, including both stockings and captures of target species, and collect and maintain specimens in a research museum.

A standardized and centralized database should be developed and maintained to incorporate the accurate compilation and storage of all relevant data, including data on population and land-use activities. The database should be made available to all resource agencies, institutions, and individuals conducting or evaluating research and management activities, as well as to the general public.

4.3 Utilize independent and autonomous peer review to guide and implement recovery actions.

An independent scientific advisory panel, with complete autonomy from all agencies, is necessary to provide an independent evaluation of Rio Grande silvery minnow research and monitoring activities. The panel should convene annually to review ongoing and proposed research and management activities. The panel should be used to assist in evaluation of research and management proposals.

5.0 Design and implement a public awareness and education program.

Public awareness of the issues and conditions that led to the Rio Grande silvery minnow's being listed as an endangered species, as well as of the recovery plan and related water resource issues, should be encouraged. Such a program should seek to educate people on the issues and the rationale for regulatory and management actions, encourage their compliance with regulations, and solicit their support for the Rio Grande silvery minnow recovery program as well as for water quality and conservation, riverine habitat, and endangered species issues in general. A good way to achieve this is through an information and education program that actively involves all stakeholders and interested parties, and makes use of several means to reach and educate people. Such a program will be implemented using the efforts of local and national staff and resources.

5.1 Issue notices regarding status of Rio Grande silvery minnow recovery effort.

The recovery team will work with the New Mexico Ecological Services Field Office to fulfill legal requirements to disseminate information about the availability of the Rio Grande Silvery Minnow Recovery Plan and any revisions. This will include posting appropriate notices in the Federal Register.

5.2 Develop and implement an outreach and communications plan for the silvery minnow.

A comprehensive outreach and communications plan will be developed jointly by members of the recovery team and the external affairs staff of the Service. Some basic considerations and ideas for such a plan are outlined below.

5.2.1 Identify key audiences.

A variety of stakeholders are interested in the Rio Grande silvery minnow recovery plan, and communication and education efforts must be tailored to each group. A first step to communicating is identifying these key audiences and their individual information needs. Audiences may include Federal, State and local governments, legislators, tribes, water users, local businesses, landowners, media (newspapers, magazines, editorial boards, conservation publications, radio, television), conservation groups, recreationists, schoolchildren, the general public, and other decision makers and opinion leaders.

5.2.2 Identify key messages.

The outreach plan should identify the key messages that need to be transmitted to all of these audiences in order to educate people on the various issues, encourage positive behavior (e.g. encourage water conservation), and/or solicit support for the recovery plan. The key messages should be tailored for the various audiences, but used consistently throughout outreach materials.

5.2.3 Develop targeted outreach programs and materials.

A wide variety of outreach programs are needed to reach the key audiences identified above. While the details of such programs will be determined as part of the outreach plan to be developed by the communications departments of the Service, the recovery team suggests the following actions.

- Develop a plan to regularly meet with various stakeholder groups, to keep them apprised of recovery plan progress, assess their concerns and how they view the recovery process, enlist their ongoing assistance in recovery efforts, and consider revisions in the plan as necessary. Such a plan should include a strategy for working with U.S. and Mexican States and tribal interests in both the U.S. and Mexico.
- Work with local and national media (including environment and agriculture reporters, editorial boards, conservation magazines, and radio and television stations) to encourage interest and accuracy in reporting.
- Develop and maintain a website focused on Rio Grande silvery minnow recovery. This may be included in (or a prominent part of) the Rio Grande Endangered Species Collaborative Program website. The website should provide access to all official reports and databases, as well as information written specifically for the general public (adults and children). It should also feature one or more email lists where interested parties can sign up to receive notice of meetings, events, new publications, comment periods, and other timely information. It might also include a weblog, where timely news and events can be posted and easily disseminated to interested parties who visit the weblog directly or subscribe to automatic updates through a feed reader. It should make use of existing educational materials, by providing prominent links to "outside" materials such as the Service's FAQ page on endangered species.
- Develop educational programs for schoolchildren. This might include programs such as Habitat Trunks, field trips to river restoration areas, and classroom materials. The Rio Grande silvery minnow website should also provide a children's section, providing easy access to endangered species education materials prepared by the Service (e.g. www.fws.gov/endangered/kids) and others.
- Enlist the assistance and expertise of outside groups in developing educational programs for adults and children, such as the National Audubon Society (children's publications), the National Wildlife Federation (www.nwf.org/wildlifeuniversity), the BioPark, and others. At a minimum, the educational programs on endangered species prepared by these groups should be easily accessible from the Rio Grande silvery minnow website.
- Establish and/or maintain opportunities where people can see captive Rio Grande silvery minnow. An informative aquarium display of live specimens can be a positive educational experience. The BioPark currently maintains one example of this. Others should be established at appropriate facilities, such as national wildlife refuges, within the area of current and historic distribution of this species.
- Develop outreach materials that educate various groups and reinforce the key messages, including public service announcements, opinion-editorial articles submitted to newspapers, targeted newsletters (such as the newsletter being prepared by the MRGESCP for irrigators, or brochures targeted for bait shops or wildlife refuge visitors), instructional videos, brochures, fact sheets, slide shows, t-shirts, bumper stickers, and posters. The website address should be prominently displayed on all materials.

- Develop materials in English and Spanish. Make many of the materials available through the Service's web site, where they can be translated into Spanish.
- Work with the MRGESCP's Public Information and Outreach workgroup to encourage interest and disseminate information.

4.3 Recovery Action Outline

1.0 Develop a thorough knowledge of the Rio Grande silvery minnow's life history, ecology, and behavior, and the current status of its habitat.

1.1 Investigate and determine biological factors.
While much has been learned about the Rio Grande silvery minnow's life history, there are still crucial gaps in our knowledge. The actions below address some of those gaps.

1.1.1 Improve our understanding of the relationship between environmental factors and spawning in the Rio Grande silvery minnow.

1.1.2 Determine distances and rates of dispersal for various life stages of Rio Grande silvery minnow.

1.1.3 Improve understanding of the ecological conditions that influence survival in different life stages of Rio Grande silvery minnow.

1.2 Investigate and improve our understanding of habitat requirements.

1.2.1 Improve understanding of habitats occupied by early life stages of Rio Grande silvery minnow.

1.2.2 Improve understanding of the stream flows that provide suitable habitat for all life stages of Rio Grande silvery minnow.

1.2.3 Develop strategic habitat restoration plans for the silvery minnow in the middle Rio Grande and elsewhere in its historical range.

1.2.4 Develop a habitat restoration monitoring program that evaluates the efficacy of habitat restoration techniques.

1.3 Continue genetic studies on Rio Grande silvery minnow populations.

1.4 Improve our understanding of the nature, extent, and role of water quality degradation in the decline of the Rio Grande silvery minnow, as well as the water quality standards necessary for its protection and recovery.

1.4.1 Continue to collect and evaluate existing data on water quality and sediment quality and identify future investigations that are needed.

1.4.2 Design and undertake toxicity tests to assess the effects of contaminants on various life stages of Rio Grande silvery minnow.

1.4.3 Design and undertake studies to assess the effects of point and non-point source discharges on Rio Grande silvery minnow food sources.

1.4.4 Design and undertake studies to assess the effects of stormwater pulse-flows (water quality and contaminants) on silvery minnow.

1.4.5 Design and undertake studies to determine the effects of various flow regimes and pollutant loading on water quality in silvery minnow habitat.

1.4.6 Determine turbidity and sediment levels that reflect ecological conditions suitable for the silvery minnow.

1.4.7 Develop water quality criteria for protection of the silvery minnow.

1.5 Improve our understanding of the nature and extent of interaction between other fish species (native and non-native) and silvery minnow, and the role of these species in the decline of silvery minnow.

1.5.1 Improve understanding of the distribution and extent of non-native fish species.

1.5.2 Improve understanding of predation and competition effects on Rio Grande silvery minnow by other native Rio Grande fish species.

1.5.3 Improve understanding of effects of different flow regimes (timing, magnitude, amplitude, duration) on non-native fishes.

1.5.4 Review and update existing regulations and policies on stocking of non-native sport fishes and bait fish use.

1.6 Investigate competitive interactions between congeners at various life stages.

1.7 Determine the nature and extent of predation on Rio Grande silvery minnow by avian and other predators.

2.0 Restore, protect, and modify habitats as necessary to alleviate threats to the Rio Grande silvery minnow.

2.1 Modify habitats as needed.

2.1.1 Implement habitat restoration projects throughout the middle Rio Gande and the historic range where appropriate.

2.1.2 Provide for fish passage at irrigation diversion structures.

2.1.3 Implement management strategies to reduce entrainment of Rio Grande silvery minnow into irrigation canals and the Low Flow Conveyance Channel.

2.1.4 Design proposed instream and floodplain projects in a manner that enhances their habitat value for the Rio Grande silvery minnow.

2.2 Provide suitable habitat for the Rio Grande silvery minnow using water management strategies for the middle Rio Grande.

2.2.1 Identify constraints (climate, depletions and other losses, reservoir operations, diversions) that affect habitat in the middle Rio Grande during periods of low flow.

2.2.2 Implement changes in river and dam operations (and other options) to enhance habitat for Rio Grande silvery minnow in the middle Rio Grande.

2.2.2.1 Retrofit or modify, if necessary, the operation of dams where sediment retention may be effectively managed for partial restoration of historic geomorphology in the middle Rio Grande.

2.2.2.2 Provide storage space for water to augment stream flow in the middle Rio Grande.

2.2.2.3 Identify how water supply and flood control operations affect riverine habitat development and habitat availability in the middle Rio Grande, and seek benefits for silvery minnow.

2.2.2.4 Provide for greater flexibility in water releases and/or storage for spawning and larval survivorship in the middle Rio Grande.

2.2.3 Encourage conjunctive use of surface water and groundwater in the middle Rio Grande.

2.2.4 Implement measures to increase water use efficiencies, water conservation, and forbearance in the middle Rio Grande valley to maintain river flows.

2.2.5 Acquire water from willing sellers or lessors for the purposes of maintaining flows for the silvery minnow in the middle Rio Grande.

2.2.6 Establish policies that limit floodplain development in the middle Rio Grande and educate the public on the need to limit such development.

2.3 Develop and implement water management strategies that will provide suitable habitat for the Rio Grande silvery minnow in areas where the species will be reintroduced (outside the middle Rio Grande).

2.3.1 Work with Mexico to provide water delivery to the Rio Grande/Rio Bravo del Norte (Big Bend region).

2.3.2 Encourage flows within the Big Bend reach that support Rio Grande silvery minnow populations.

2.3.3 Evaluate and implement, if appropriate, changes in river and reservoir operations to enhance habitat for silvery minnow in reintroduced areas.

2.3.3.1 Provide for storage of water to augment streamflow in reintroduced areas.

2.3.3.2 Within existing legal authorities, identify how reservoir operations for water conveyance affect riverine habitat development and habitat availability in reintroduced areas.

2.3.4 Investigate legal, institutional, and technical feasibility of implementing a program of conjunctive use of surface and groundwater in reintroduced areas.

2.3.5 Implement measures to increase water use efficiencies and conservation in reintroduced areas.

2.3.6 Implement a comprehensive program of data collection on water supply and use for improvement of water and habitat management in reintroduced areas.

2.3.7 Retrofit or change the operation of inflow gates at dams where sediment retention is detrimental to the appropriate geomorphology in reintroduced areas.

2.3.8 Establish policies that limit floodplain development in reintroduced areas and educate the public on the need to limit such development in reintroduced areas.

2.3.9 Investigate the potential of habitat construction that, during periods of low flow, will provide suitable habitat for the silvery minnow in reintroduced areas.

3.0 Ensure the survival of the Rio Grande silvery minnow in its current habitat and reestablish the species into suitable habitats in its historical range.

3.1 Continue Rio Grande silvery minnow captive propagation activities.

3.1.1 Annually update a controlled propagation plan for long-term Rio Grande silvery minnow propagation activities.

3.1.2 Evaluate and annually refine methods of Rio Grande silvery minnow propagation.

3.1.3 Continue genetic monitoring and study of propagated Rio Grande silvery minnow.

3.1.4 Continue the use of propagated Rio Grande silvery minnow for scientific research.

3.1.4.1 Develop a larval fish key for the middle Rio Grande and for stream segments where reintroductions are likely.

3.1.4.2 Determine the efficacy of various methods for marking Rio Grande silvery minnow (all life stages).

3.1.4.3 Determine the role of environmental parameters in sex determination of Rio Grande silvery minnow.

3.1.4.4 Determine the rate of development and hatching success under various environmental conditions for Rio Grande silvery minnow.

3.2 Continue Rio Grande silvery minnow augmentation activities.

3.2.1 Annually review and revise the Rio Grande silvery minnow augmentation plan for the middle Rio Grande.

3.2.2 Coordinate augmentation needs with propagation activities.

3.2.3 Improve our understanding of the effects of various stocking conditions and release sites on Rio Grande silvery minnow.

3.2.4 Determine the effects of hatchery-to-release site transport conditions on stocked Rio Grande silvery minnow.

3.3 Reestablish Rio Grande silvery minnow at appropriate locations in its historical range.

3.3.1 Develop a master plan for reestablishment of Rio Grande silvery minnow within its historic range.

3.3.2 Develop and implement a site-specific plan for each reintroduction location that delineates actions necessary for reestablishment of Rio Grande silvery minnow.

3.3.3 Monitor the reintroduced populations of Rio Grande silvery minnow.

3.4 Develop population viability models to assess extinction probabilities for existing and reintroduced populations.

4.0 Implement and maintain an adaptive management program so that appropriate research and management activities are implemented in a timely manner to achieve recovery of the Rio Grande silvery minnow.

4.1 Develop and annually review interim workplans to ensure progress toward recovery of the silvery minnow.

4.2 Continue long-term Rio Grande silvery minnow monitoring programs through downlisting and post delisting.

4.2.1 Use the Middle Rio Grande Long-Term Fish Population Monitoring Program methodology as the model in the development and implementation of a sampling protocol for a long-term fish monitoring program.

4.2.2 Develop and implement a sampling methodology of sufficient rigor to generate a statistically reliable population estimate for each population of Rio Grande silvery minnow.

4.2.3 Establish and maintain a single, centralized, standardized database for storage and retrieval of hydrologic, biologic, economic, and social data, including both stockings and captures of target species, and collect and maintain specimens in a research museum.

4.3 Utilize independent and autonomous peer review to guide and implement recovery actions.

5.0 Design and implement a public awareness and education program.

5.1 Issue notices regarding status of Rio Grande silvery minnow recovery effort.

5.2 Develop and implement an outreach and communications plan for the silvery minnow.

5.2.1 Identify key audiences.

5.2.2 Identify key messages.

5.2.3 Develop targeted outreach programs and materials.

5.0 ADDRESSING THREATS

5.1 Summary of Listing Factors and Threats, and the Recovery Criteria and Recovery Actions That Address Them (Threats Tracking Table)

The table below provides a cross-check of how the recovery criteria and recovery actions contained in the Rio Grande Silvery Minnow Recovery Plan address the five listing factors and the specific threats to the species. For a thorough review of the threats, see Section 1.7.

Table 2. Threats Tracking Table

LISTING FACTOR	THREAT	RECOVERY CRITERIA	RECOVERY ACTIONS
A. The present or threatened destruction, modification, or curtailment of its habitat or range	Dewatering and Diversion • Annual dewatering of a large percentage of the species' habitat • Risk of two consecutive below-average flow years, which can affect short-lived species • Increase in non-native and exotic fish species • Increase in contaminant concentrations during low flows, which may exacerbate other stresses • Entrainment of eggs and young-of-year in diversion structures • Fragmented habitat	1-A-1 1-A-2 2-A-1 2-A-2 2-B-1 2-B-2 3-A-1 3-A-2 3-B-1 3-B-2	1.1 Investigate biological factors 1.2 Understand habitat needs 2.1 Modify habitats 2.2 Provide suitable habitat using water management strategies 2.3 Develop habitat-enhancing water mgmt strategies for reintroduction areas 3.3 Conduct reintroductions 4.1 Develop interim workplans 4.2 Continue long-term monitoring 4.3 Utilize independent scientific advisory panel 5.1 Issue notices of recovery effort 5.2 Develop outreach plan
	Water impoundment • Altered flow regimes • Prevention of overbank flooding • Trapped nutrients • Altered sediment transport regimes • Prolonged summer base flows • Reduced food supply • Altered preferred habitat • Prevention of species' dispersal	1-A-1 1-A-2 2-A-1 2-A-2 2-B-1 2-B-2 3-A-1 3-A-2 3-B-1 3-B-2	1.1 Investigate biological factors 1.2 Understand habitat needs 2.1 Modify habitats 2.2 Provide suitable habitat using water management strategies 2.3 Develop habitat-enhancing water mgmt strategies for reintroduction areas 3.3 Conduct reintroductions 4.1 Develop interim workplans 4.2 Continue long-term monitoring

LISTING FACTOR	THREAT	RECOVERY CRITERIA	RECOVERY ACTIONS
	• Creation of reservoirs and altered flow regimes that favor non-native fish species that may compete with or prey upon the species • Stored spring runoff and summer inflow, which would normally cause flooding • Reduced flows, which may limit the amount of preferred habitat and limit dispersal of the species • Lack of suitable habitat for young-of-year • Fragmented habitat		4.3 Utilize independent peer review 5.1 Issue notices of recovery effort 5.2 Develop outreach plan
	River modification • Confined flood flows • Trapped sediment • Establishment of stabilizing vegetation • Elimination of meanders, oxbows and other components of historic aquatic habitat • Replacement of preferred sand and silt substrate with gravel and cobble • Reduction of floodplain areas where young can develop • Geomorphological changes to the river channel	1-A-1 1-A-2 2-A-1 2-A-2 2-B-1 2-B-2 3-A-1 3-A-2 3-B-1 3-B-2	1.1 Investigate biological factors 1.2 Understand habitat needs 2.1 Modify existing habitats 2.2 Provide suitable habitat using water management strategies 2.3 Develop habitat-enhancing water management strategies for reintroduction areas 3.3 Conduct reintroductions 4.1 Develop interim workplans 4.2 Continue long-term monitoring 4.3 Utilize independent peer review 5.1 Issue notices of recovery effort 5.2 Develop outreach plan
	Water pollutants • Poor water quality caused by agriculture and urbanization in the Rio Grande basin, especially during low flows and storm events	2-B-1 2-B-2 2-D-1 3-B-1 3-B-2 3-C-1	1.4 Determine water quality 4.1 Develop interim workplans 4.2 Continue long-term monitoring 4.3 Utilize independent peer review 5.1 Issue notices of recovery effort 5.2 Develop outreach plan
B. Overutilization for commercial, recreational, scientific, or	• Possible over-utilization through scientific collecting • Licensed commercial bait dealers possibly selling bait minnows	1-A-1 1-A-2 2-A-1 2-A-2	4.1 Develop interim workplans 4.2 Continue long-term monitoring 4.3 Utilize independent peer review 5.1 Issue notices of recovery effort

LISTING FACTOR	THREAT	RECOVERY CRITERIA	RECOVERY ACTIONS
educational purposes	• Incidental utilization of species during legal collection of bait minnows for personal use	3-A-1 3-A-2	5.2 Develop outreach plan
C. Disease or predation	Disease • Risk of stress and disease when RGSM are confined to pools during periods of low flows • Increased risk of stress-induced disease outbreaks possibly exacerbated when high levels of pollutants or other stresses are present Predation • Predation by non-native fishes, as well as birds and mammals, • Competition for space and food with non-native fish	1-A-1 1-A-2 2-A-1 2-A-2 2-B-1 2-B-2 3-A-1 3-A-2 3-B-1 3-B-2	1.5 Understand interactions with other fish species 1.7 Understand predation by other species 4.1 Develop interim workplans 4.2 Continue long-term monitoring 4.3 Utilize independent peer review 5.1 Issue notices of recovery effort 5.2 Develop outreach plan
D. Inadequacy of existing regulatory mechanisms	• No protection of habitat under State law • Inability to acquire instream water rights for the benefit of fish and wildlife • Inadequate regulations to restrict the use of bait fish, illegal use of bait fish, introduction of non-natives via bait bucket, introduction of disease or parasites by importation of bait fish.	1-A-1 1-A-2 2-A-1 2-A-2 2-B-1 2-B-2 3-A-1 3-A-2 3-B-1 3-B-2	1.4 Understand water quality effects 1.5 Understand interactions with other fish species 4.1 Develop interim workplans 4.2 Continue long-term monitoring 4.3 Utilize independent peer review 5.1 Issue notices of recovery effort 5.2 Develop outreach plan
E. Other natural or manmade factors affecting its continued existence	• Reduced population numbers and potential loss of genetic diversity • Introduction and subsequent competition from non-native fish	1-A-1 1-A-2 1-B-1 2-A-1 2-A-2 2-C-1 3-A-1 3-A-2	1.1 Investigate biological factors 1.2 Understand habitat needs 1.3 Continue genetic studies 1.5 Understand interactions with other fish species 1.6 Understand threats from congeners 3.1 Continue captive propagation 3.2 Continue augmentation activities 3.3 Conduct reintroductions 4.1 Develop interim workplans

LISTING FACTOR	THREAT	RECOVERY CRITERIA	RECOVERY ACTIONS
			4.2 Continue long-term monitoring 4.3 Utilize independent peer review 5.1 Issue notices of recovery effort 5.2 Develop outreach plan

6.1 Introduction

The Implementation Schedule below outlines actions and estimated costs for the recovery program for the Rio Grande silvery minnow, as set forth in this plan. It is a guide for meeting the recovery goals. This schedule indicates action priorities, action numbers, action descriptions, duration of actions, parties responsible for actions, the threats and recovery criteria that are addressed by specific actions, and estimated costs. A brief description of the agencies involved also follows.

The implementation of actions identified in this plan is not the sole responsibility of the Service. Although the Service provides leadership in the recovery of listed species, other Federal, State, and local agencies, as well as Indian pueblos and private citizens, all play a vital role. In particular, the MRGESCP coordinates Federal and other activities that promote the protection and recovery of the Rio Grande silvery minnow, and thus serves as an implementation vehicle for many of the actions described in this plan.

Parties with authority, responsibility, or expressed interest to implement a specific recovery action are identified in the Implementation Schedule. Where more than one party is identified, the proposed lead party is listed first. The listing of a party in the schedule does not require the identified party to implement the action(s) or to secure funding for implementing the action(s).

The priority levels assigned to actions are defined as follows:

- Priority Level 1: An action that must be taken to prevent extinction or to prevent the species from declining irreversibly.
- Priority Level 2: An action that must be taken to prevent a significant decline in species population/habitat quality, or helps improve the status so that downlisting may be considered.
- Priority Level 3: All other actions necessary to provide for full recovery of the species.

6.2 Implementation Schedule

Priority	Action #	Action Description	Criterion	Duration	Responsible Parties	FWS Lead	Estimated Costs ($1000s)								Comments
							Total	FY 10	FY 11	FY 12	FY 13	FY 14	FY 15-19	FY 20-35	
							167700	9000	18780	10980	16005	19520	66885	26530	
1	3.1.1	Annually update a controlled propagation plan for long-term Rio Grande silvery minnow propagation activities.	2-A-3, 3-A-1	25 yrs	FWS, MRGESCP	Yes	390	15	15	15	15	15	90	225	$50K in ’06 to develop plan, $15 to refine annually
1	3.1.2	Evaluate and annually refine methods of Rio Grande silvery minnow propagation	1-B-1, 2-A-3, 3-A-1	25 yrs	FWS	Yes	200	10	10	10	10	10	50	100	Plan complete, revise as needed.
1	3.1.3	Continue genetic monitoring and study of propagated Rio Grande silvery minnow.	1-B-1, 2-A-3, 3-A-1	25 yrs	MRGESCP	No	425	50	50	75	25	25	100	100	
1	3.2.1	Annually review and revise the Rio Grande silvery minnow augmentation plan for the middle Rio Grande.	2-A-3, 3-A-1	25 yrs	FWS, MRGESCP	Yes	390	15	15	15	15	15	90	225	Same as 3.1.1
1	4.2.1	Use the Middle Rio Grande Long-Term Fish Population Monitoring Program methodology as the model in the development and implementation of a sampling protocol for a long-term fish monitoring program.	1-A-1, 1-A-2, 2-A-3, 3-A-1	5 yrs	FWS, MRGESCP	Yes	1250	250	250	250	250	250			

Priority	Action #	Action Description	Criterion	Duration	Responsible Parties	FWS Lead	Estimated Costs ($1000s)								Comments
							Total	FY 10	FY 11	FY 12	FY 13	FY 14	FY 15-19	FY 20-35	
							167700	9000	18780	10980	16005	19520	66885	26530	
2	1.3	Continue genetic studies on Rio Grande silvery minnow populations.	1-A-1, 2-A-3, 3-A-1	1 ea. 3 yrs	MRGESCP	No	575				75		250	250	
2	3.4	Develop population viability models to assess extinction probabilities for existing and reintroduced populations.	1-A-1, 2-A-3, 3-A-1	3 yrs	FWS, MRGESCP	yes	550	50	50	50	75	75	100	150	
2	4.1	Develop and annually review interim workplans to ensure progress toward recovery of the silvery minnow	All	25 years	FWS	Yes	265	10	10	10	25	10	50	150	1 each 5 yrs
2	4.3	Utilize independent and autonomous peer review to guide and implement recovery actions.	All	1 per 5 yrs	FWS, MRGESCP	Yes	600			100		100	200	200	
2	1.1.1	Improve understanding of the relationship between environmental factors and spawning in the Rio Grande silvery minnow.	1-A-2, 2-A-2, 2-B-2, 2-B-3, 3-B-2, 3-B-3	3 yrs	FWS, MRGESCP	Yes	450	150	150	150					Larval development and thermal regimes funded FY10
2	1.1.2	Determine distances and rates of dispersal for various life stages of Rio Grande silvery minnow.	2-B-3, 3-B-3	3 yrs	MRGESCP	Yes	450		150	150	150				PIT tag study in 3rd year to evaluate movement of adults; subadult study needed

Priority	Action #	Action Description	Criterion	Duration	Responsible Parties	FWS Lead	Estimated Costs ($1000s)								Comments
							Total	FY 10	FY 11	FY 12	FY 13	FY 14	FY 15-19	FY 20-35	
							167700	9000	18780	10980	16005	19520	66885	26530	
2	1.1.3	Improve understanding of the ecological conditions that influence survival in different life stages of Rio Grande silvery minnow.	1-A-1, 2-A-1, 2-A-3, 2-B-1, 2-B-3, 2-B-4, 3-A-1, 3-B-1, 3-B-3, 3-B-4	5 yrs	MRGESCP	No	300				100	100	100		
2	1.2.1	Improve understanding of habitats occupied by early life stages of Rio Grande silvery minnow.	2-B-3, 3-B-3	3 yrs	MRGESCP	No	375		125	125	125				
2	1.2.2	Improve understanding of the stream flows that will provide suitable habitat for all life stages of Rio Grande silvery minnow.	1-A-1, 2-B-1, 2-B-3, 3-B-1, 3-B-3	5 yrs	MRGESCP	No	400					100	300		
2	1.2.3	Develop strategic habitat restoration plans for the silvery minnow in the middle Rio Grande and elsewhere in its historical range	1-A-1, 2-A-1, 2-A-3, 2-B-1, 2-B-3, 2-B-4, 3-A-1, 3-B-1, 3-B-3, 3-B-4	5 yrs	FWS, MRGESCP, TPWD	Yes	900		200		200	250	250		Plans underway/complete in the middle Rio Grande
2	1.2.4	Develop a habitat restoration monitoring program that evaluates the efficacy of habitat restoration techniques	1-A-1, 2-B-3, 3-B-3	5 yrs	MRGESCP	No	300	50	250						

Priority	Action #	Action Description	Criterion	Duration	Responsible Parties	FWS Lead	Estimated Costs ($1000s)								Comments
							Total	FY 10	FY 11	FY 12	FY 13	FY 14	FY 15-19	FY 20-35	
							167700	9000	18780	10980	16005	19520	66885	26530	
2	1.4.1	Continue to collect and evaluate existing data on water quality and sediment quality and identify future investigations that are needed.	2-B-4, 3-B-4	3 yrs	FWS, MRGESCP	Yes	600			200	200	200			
2	1.4.2	Design and undertake toxicity tests to assess the effects of contaminants on various life stages of Rio Grande silvery minnow.	2-B-4, 3-B-4	3 yrs	FWS, USGS, NMED, MRGESCP	Yes	600			200	200	200			
2	1.4.3	Design and undertake studies to assess the effects of point and non-point source discharges on Rio Grande silvery minnow food sources.	1-A-1, 2-B-4, 3-B-4	3 yrs	FWS, UNM, MRGESCP	Yes	600				200	200	200		Periphyton studies underway at UNM (Bixby)
2	1.4.4	Design and undertake studies to assess the effects of stormwater pulse-flows (water quality and contaminants) on Rio Grande silvery minnow	1-A-1, 2-B-4, 3-B-4	3 yrs	MRGESCP	No	450			150	150	150			
2	1.4.5	Design and undertake studies to determine the effects of various flow regimes and pollutant loading on water quality in silvery minnow habitat.	1-A-1, 2-B-4, 3-B-4	3 yrs	FWS, MRGESCP	Yes	450		150	150	150				

Priority	Action #	Action Description	Criterion	Duration	Responsible Parties	FWS Lead	Estimated Costs ($1000s)								Comments
							Total	FY 10	FY 11	FY 12	FY 13	FY 14	FY 15-19	FY 20-35	
							167700	9000	18780	10980	16005	19520	66885	26530	
2	1.4.6	Determine turbidity and sediment levels that reflect ecological conditions suitable for the Rio Grande silvery minnow.	2-B-3, 3-B-3	5 yrs	States, tribes, EPA	No	300					100	200		
2	2.1.1	Implement habitat restoration projects throughout the middle Rio Grande and the historic range where appropriate.	2-B-3, 3-B-3	10 yrs	MRGESCP, FWS, IBWC, TPWD	Yes in reintroduction areas, MRGESCP in middle Rio Grande	47000	3000	3000	3000	3000	10000	25000		
2	2.1.2	Provide for fish passage at irrigation diversion structures.	2-A-1, 2-A-3, 3-A-1	10 yrs	BOR	No	22100	200	9000	450	4000	450	8000		SADD passage construction in FY10
2	2.1.3	Implement management strategies to reduce entrainment of Rio Grande silvery minnow into irrigation canals and the Low Flow Conveyance Channel.	1-A-1, 2-A-1	ongoing	MRGCD, BOR, FWS	No	75	5	5	5	5	5	25	25	annual coordination to manage diversions during spawning
2	2.2.1	Identify constraints (climate, depletions and other losses, reservoir operations, diversions) that affect habitat during periods of low flow.	2-B-1, 2-B-3, 3-B-1, 3-B-3	5 yrs	BOR, COE	No	500		100	100	100	100	100		

Priority	Action #	Action Description	Criterion	Duration	Responsible Parties	FWS Lead	Estimated Costs ($1000s)								Comments
							Total	FY 10	FY 11	FY 12	FY 13	FY 14	FY 15-19	FY 20-35	
							167700	9000	18780	10980	16005	19520	66885	26530	
2	2.2.2.1	Retrofit or modify, if necessary, the operation of dams where sediment retention may be effectively managed for partial restoration of historic geomorphology in the middle Rio Grande.	2-B-2, 2-B-3, 3-B-2, 3-B-3	5 yrs	COE, BOR	No	30						30		
2	2.2.2.2	Provide storage space for water to augment stream flow in the middle Rio Grande.	1-A-1, 2-A-1, 2-B-1, 3-B-1	5 yrs	COE, BOR	No	1550		175	275	275	275	550		
2	2.2.2.3	Identify how water supply and flood control operations affect riverine habitat development and habitat availability, in the middle Rio Grande and seek benefits for the silvery minnow.	2-B-2, 2-B-3, 3-B-2, 3-B-3	3 yrs	MRGESCP	No	300		100	100	100				
2	2.2.2.4	Provide for greater flexibility in water releases and/or storage for spawning and larval survivorship in the middle Rio Grande.	1-A-1, 2-A-1, 3-A-1	5 yrs	COE	No	260	10	10	10	10	10	60	150	Cochiti Deviation agreement in place through 2013; costs are for operations and coordination

Priority	Action #	Action Description	Criterion	Duration	Responsible Parties	FWS Lead	Estimated Costs ($1000s)								Comments
							Total	FY 10	FY 11	FY 12	FY 13	FY 14	FY 15-19	FY 20-35	
							167700	9000	18780	10980	16005	19520	66885	26530	
2	2.2.5	Acquire water from willing sellers or lessors for the purposes of maintaining flows for the silvery minnow in the middle Rio Grande.	1-A-1, 2-A-1, 3-A-1	annual	BOR	No	60000	4000	4000	4000	4000	4000	20000	20000	
2	3.1.4.1	Develop a larval fish key to the middle Rio Grande and for stream segments where reintroductions are likely.	2-A-3, 3-A-1	1 yrs	BOR, FWS	No	0								Funded by BOR in FY 09
2	3.1.4.2	Determine the efficacy of various methods for marking Rio Grande silvery minnow (all life stages)	1-A-1, 1-A-2, 2-B-1,2-B-2, 2-B-3, 3-B-1, 3-B-2, 3-B-3	3 yrs	FWS	Yes	150			50	50	50			Adult marking methods have been tested; subadult studies needed
2	3.1.4.3	Determine the role of environmental parameters in sex determination of Rio Grande silvery minnow.	2-B-2, 2-B-3, 3-B-2, 3-B-3	3 yrs	MRGESCP	No	225			75	75	75			

Priority	Action #	Action Description	Criterion	Duration	Responsible Parties	FWS Lead	Estimated Costs ($1000s)								Comments
							Total	FY 10	FY 11	FY 12	FY 13	FY 14	FY 15-19	FY 20-35	
							167700	9000	18780	10980	16005	19520	66885	26530	
2	3.1.4.4	Determine the rate of development and hatching success under various environmental conditions for Rio Grande silvery minnow.	1-A-2, 2-A-2, 2-B-2,3-B-2	3 yrs	FWS, MRGESCP	Yes	300		100	100	100				
2	3.2.2	Coordinate augmentation needs with propagation activities	1-A-1, 1-B-1, 2-A-3, 3-A-1	25 yrs	FWS	Yes	200	10	10	10	10	10	50	100	
2	3.2.3	Improve our understanding of the effects of various stocking conditions and release sites on Rio Grande silvery minnow.	2-A-3, 3-A-1	5 yrs	FWS, MRGESCP	Yes	125		25	25	25	25	25		

Priority	Action #	Action Description	Criterion	Duration	Responsible Parties	FWS Lead	Estimated Costs ($1000s)								Comments
							Total	FY 10	FY 11	FY 12	FY 13	FY 14	FY 15-19	FY 20-35	
							167700	9000	18780	10980	16005	19520	66885	26530	
2	3.2.4	Determine the effects of hatchery-to-release site transport conditions on stocked Rio Grande silvery minnow.	2-A-3, 3-A-1	2 yrs	FWS,	Yes	50	25	25						
2	3.3.1	Develop a plan for reestablishment of Rio Grande silvery minnow for each reintroduction location.	2-A-3, 3-A-1	16 yrs	FWS	Yes	960		40	40	40	40	400	400	Big Bend Plan complete, update as needed
2	3.3.3	Monitor the reintroduced populations of Rio Grande silvery minnow.	2-A-3, 3-A-1	15 yrs	FWS	Yes	2275	75	75	75	150	150	750	1000	Costs increase as populations are added
3	1.7	Determine the nature and extent of predation on Rio Grande silvery minnow by avian and other predators.	2-A-3, 3-A-1	3 yrs	MRGESCP	No	275				100	100	75		

Priority	Action #	Action Description	Criterion	Duration	Responsible Parties	FWS Lead	Estimated Costs ($1000s)								Comments
							Total	FY 10	FY 11	FY 12	FY 13	FY 14	FY 15-19	FY 20-35	
							167700	9000	18780	10980	16005	19520	66885	26530	
3	5.1	Issue notices regarding status of Rio Grande silvery minnow recovery effort.	All	25 years	FWS	Yes	50				10		20	20	1 each 5 yrs
3	5.3	Develop and implement an outreach and communications plan that will help all interested parties to better understand the Rio Grande silvery minnow and its habitat, as well as related conservation and water management issues.	All	1 yr	FWS	Yes	25					25			
3	1.4.7	Develop water quality criteria for protection of the Rio Grande silvery minnow.	2-B-4, 3-B-4	5 yrs.	States, tribes, EPA	No	200					100	100		
3	1.5.1	Improve understanding of the distribution and extent of non-native fish species.	2-A-3, 3-A-1	5 yrs	NMDGF, MRGESCP	No	250						250		
3	1.5.2	Improve our understanding of predation and competition effects on Rio Grande silvery minnow by other Rio Grande fish species.	2-A-3, 3-A-1	3 yrs	NMDGF, TPWD	No	650					150	500		

Priority	Action #	Action Description	Criterion	Duration	Responsible Parties	FWS Lead	Estimated Costs ($1000s)								Comments
							Total	FY 10	FY 11	FY 12	FY 13	FY 14	FY 15-19	FY 20-35	
							167700	9000	18780	10980	16005	19520	66885	26530	
3	1.5.3	Improve understanding of the effects of different flow regimes (timing, magnitude, duration) on non-native fishes.	2-B-3, 3-B-3	5 yrs	MRGESCP	No	625					125	500		
3	1.5.4	Review and update existing regulations and policies on stocking of non-native sport fishes and bait fish use.	1-A-1, 2-A-3, 3-A-1	1 yr	NMDGF, TPWD	No	75			75					
3	1.6.	Investigate competitive interactions between congeners at various life stages.	2-A-3, 3-A-1	3 yrs	MRGESCP	No	300				100	100	100		
3	2.1.4	Design proposed instream and floodplain projects in a manner that enhances their habitat value for the Rio Grande silvery minnow.	1-A-1, 2-B-3, 3-B-3	25 yrs	BOR, COE	No	625	25	25	25	25	25	250	250	
3	2.2.3	Encourage conjunctive use of surface water and groundwater in the Rio Grande.	2-B-2, 2-B-3, 3-B-2, 3-B-3	10 yrs	OSE	No	25		5	5	5	5	5		

Priority	Action #	Action Description	Criterion	Duration	Responsible Parties	FWS Lead	Estimated Costs ($1000s)								Comments
							Total	FY 10	FY 11	FY 12	FY 13	FY 14	FY 15-19	FY 20-35	
							167700	9000	18780	10980	16005	19520	66885	26530	
3	2.2.4	Implement measures to increase water use efficiencies, water conservation, and forbearance in the middle Rio Grande valley to maintain river flows.	1-A-1	10 yrs	MRGCD, COE, BOR	No	900		100	100	100	100	500		
3	2.2.6	Establish policies that limit floodplain development in the middle Rio Grande and educate the public on the need to limit such development.	1-A-1, 2-B-2, 2-B-3, 3-B-2, 3-B-3	5 yrs	COE, BOR	No	40		10	10	10	5	5		Policy development followed by outreach
3	2.3.1	Work with Mexico to provide water delivery to the Rio Grande/Rio Bravo del Norte (Big Bend region).	2-B-1, 3-B-1	15 yrs	FWS, IBWC, TCEQ	Yes	60				5	5	50		
3	2.3.2	Encourage flows within the Big Bend reach that support Rio Grande silvery minnow populations.	2-B-1, 3-B-1	15 yrs	IBWC, TCEQ	No	75				5	5	5	60	
3	2.3.3.1	Provide for storage of water to augment stream flow in reintroduced areas.	1-A-1, 1-A-2, 2-B-1, 3-B-1	5 yrs	IBWC, TCEQ	No	5000				1000	1000	3000		

Priority	Action #	Action Description	Criterion	Duration	Responsible Parties	FWS Lead	Estimated Costs ($1000s)								Comments
							Total	FY 10	FY 11	FY 12	FY 13	FY 14	FY 15-19	FY 20-35	
							167700	9000	18780	10980	16005	19520	66885	26530	
3	2.3.3.2	Identify how reservoir operations for water conveyance affect riverine habitat development and habitat availability.	2-B-3,3-B-3	5 yrs	COE, BOR, FWS	No	500			100	100	100	200		
3	2.3.4	Investigate legal, institutional, and technical feasibility of implementing a program of conjunctive use of surface and ground water in reintroduced areas.	1-A-1, 2-B-1	5 yrs	FWS, IBWC, TCEQ, OSE	Yes	25				5	5	15		
3	2.3.5	Implement measures to increase water use efficiencies and conservation in reintroduced areas.	1-A-1, 2-B-1, 2-B-3, 3-B-1, 3-B-3	10 yrs	FWS, IBWC, TCEQ, OSE	Yes	600		100	100	50	50	300		
3	2.3.6	Implement a comprehensive program of data collection on water supply and use for improvement of water and habitat management in reintroduced areas.	2-B-1, 2-B-3, 3-B-1, 3-B-3	25 yrs	TCEQ, FWS, IBWC	No	700			150	25	25	250	250	Database dev. in 1st yr. $25k/yr to maintain
3	2.3.7	Retrofit or change the operation of inflow gates at dams where sediment retention is detrimental to the appropriate geomorphology in reintroduced areas.	2-B-3, 3-B-3	10 yrs	IBWC, COE, BOR	No	1750		175	175	175	175	1050		

Priority	Action #	Action Description	Criterion	Duration	Responsible Parties	FWS Lead	Estimated Costs ($1000s)								Comments
							Total	FY 10	FY 11	FY 12	FY 13	FY 14	FY 15-19	FY 20-35	
							167700	9000	18780	10980	16005	19520	66885	26530	
3	2.3.8	Establish policies that limit floodplain development in reintroduced areas and educate the public on the need to limit such development in reintroduced areas.	2-B-3, 3-B-3	5 yrs	COE, States	No	35				10	10	15		Policy development followed by outreach
3	2.3.9	Investigate the potential of habitat construction that, during periods of low flow, will provide suitable habitat for the silvery minnow in reintroduced areas.	2-B-3, 3-B-3	3 yrs	FWS, TPWD, IBWC, BOR	Yes	300				100	100	100		
3	4.2.2	Develop and implement a sampling methodology of sufficient rigor to generate a statistically reliable population estimate for each population of Rio Grande silvery minnow.	1-A-1, 2-A-1, 3-A-1	25 yrs	MRGESCP	No	6250	250	250	250	250	250	2500	2500	Three year pilot study complete. Funding for additional refinement and estimation

Priority	Action #	Action Description	Criterion	Duration	Responsible Parties	FWS Lead	Estimated Costs ($1000s)								Comments
							Total	FY 10	FY 11	FY 12	FY 13	FY 14	FY 15-19	FY 20-35	
							167700	9000	18780	10980	16005	19520	66885	26530	
3	4.2.3	Establish and maintain a single, centralized, standardized database for storage and retrieval of hydrologic, biologic, economic, and social data, including both stockings and captures of target species, and collect and maintain specimens in a research museum.	All	25 yrs	MRGESCP, FWS	No	1400	800	25	25	25	25	125	375	Database development started in 08 may be complete by 2010; estimated $25k/yr to maintain.
3	5.2.2	Identify key messages.	1-A-1, 2-A-1, 3-A-1	1 yr	FWS	Yes	200	10	10	10	10	10	50	100	Plan complete, revise as needed.
3	5.2.3	Develop targeted outreach programs and materials.	All	1 yr	FWS	Yes	425	50	50	75	25	25	100	100	
3	5.3.1	Identify key audiences.	2-A-3, 3-A-1	1 yr	FWS	Yes	390	15	15	15	15	15	90	225	Same as 3.1.1

6.3 Responsible Parties

For the purposes of recovery planning, the Service defines "Responsible Parties" as the best lead party or parties to accomplish a given recovery action. Inclusion under this section does not obligate any party to implement the recovery plan, but merely identifies the best candidate for completing the action. In some cases, tribes or pueblos may be the most appropriate party for implementing certain recovery activities. Implementation of recovery actions by tribes or pueblos is strictly voluntary.

Following are brief descriptions of some of the entities participating in the recovery of the Rio Grande silvery minnow.

6.3.1 U.S. Fish and Wildlife Service (FWS, Service)

The mission of the Service is: working with others to conserve, protect and enhance fish, wildlife, and plants and their habitats for the continuing benefit of the American people. Protecting endangered and threatened species and restoring them to a secure status in the wild is the primary objective of the endangered species program of the Service, an agency of the U.S. Department of the Interior. Responsibilities of the endangered species program include: listing, reclassifying, and delisting species under the Endangered Species Act; consulting with Federal agencies on their activities that may affect listed species; overseeing recovery activities for listed species; providing for the protection of important habitat; and providing grants to States to assist with endangered species conservation efforts.

6.3.2 U.S. Bureau of Reclamation (BOR)

The mission of BOR is to manage, develop, and protect water and related resources in an environmentally and economically sound manner in the interest of the American public. The agency operates and maintains all or part of the works associated with the following major water supply projects, all of which affect the water resources within the historic habitat of the Rio Grande silvery minnow: the San Luis Valley Project, the San Juan-Chama Project, the Middle Rio Grande Project and the Rio Grande Project, the Carlsbad Project, and the Brantley Project.

6.3.3 U.S. Army Corps of Engineers (COE)

The COE is authorized to operate and maintain the following projects affecting the water resources within the historic habitat of the Rio Grande silvery minnow: Platoro Dam (flood control pool only), Middle Rio Grande Project (Abiquiu, Cochiti, Jemez Canyon, and Galisteo Dams) and Santa Rosa, Sumner, Brantley (flood control pools only) and Two Rivers Dam in the Pecos River Basin. The COE is also responsible for issuing permits for the discharge of dredged or fill material into the navigable waters of the United States, under section 404 of the Clean Water Act (Federal Water Pollution Control Act).

6.3.4 U.S. Environmental Protection Agency (EPA)

The mission of the EPA is to protect human health and to safeguard the natural environment (air, water, and land) upon which life depends. Among other things, the agency is responsible for the administration of certain provisions of the Clean Water Act, including the issuance of permits for the discharge of pollutants under the National Pollution Discharge Elimination System.

6.3.5 New Mexico Interstate Stream Commission (ISC) and Office of the State Engineer (OSE)

The ISC and the OSE are separate but companion agencies charged with administering the State's water resources. The agencies have authority over the supervision, measurement, appropriation, and distribution of almost all surface and groundwater in New Mexico, including streams and rivers that cross State boundaries. The State Engineer is also secretary to the ISC and oversees the staff of both agencies.

6.3.6 New Mexico Environment Department – Surface Water Quality Bureau

The mission of the Surface Water Quality Bureau is to preserve, protect, and improve New Mexico's surface water quality for present and future users of these resources. Emphasis is placed on the maintenance of water quality adequate to guarantee the continuation, in perpetuity, of the potential and existing uses of the water through evaluation, education, and outreach activities, point and nonpoint source controls, and wastewater operator training and certification. The Surface Water Quality Bureau utilizes the authorities described in the Federal Clean Water Act and Safe Drinking Water Act, as well as the New Mexico Water Quality Act and Utility Operators Act, and their attendant regulations and standards.

6.3.7 New Mexico Department of Game and Fish (NMDGF)

Under the authority of the New Mexico Wildlife Conservation Act (NMSA 17-2-37 through 17-2-46, 1978), the NMDGF is responsible for identifying and protecting endangered wildlife in New Mexico. The NMDGF also has responsibility under NMSA 75-6-1 to protect endangered plants.

6.3.8 Texas Parks and Wildlife Department (TPWD)

The TPWD maintains a list of endangered species in the State and manages their recovery. "Endangered" species are those that the Executive Director of TPWD has named as being threatened with statewide extinction. "Threatened" species are those that the TPWD Commission has determined are likely to become endangered in the future.

6.3.9 The Texas Commission on Environmental Quality (TCEQ)

The mission of the TCEQ is to protect the State's human and natural resources consistent with sustainable economic development. The TCEQ's goal is clean air, clean water, and safe management of waste with an emphasis on pollution prevention.

6.3.10 Texas-New Mexico Water Commission

The Texas-New Mexico Water Commission, which includes representatives of water user groups from the lower Rio Grande in New Mexico and Texas, was formed after a negotiated settlement of disputes surrounding the use of groundwater resources and the effect of surface water uses on aquifer levels in the Mesilla Basin. A goal of the settlement agreement entered into between the parties in 1991 was to work together to study, identify, and address common concerns, especially the interaction between the surface water and the groundwater in the Mesilla Basin of New Mexico and Texas.

6.3.11 Middle Rio Grande Conservancy District (MRGCD)

The MRGCD, a political subdivision of the State of New Mexico, was organized under the 1927 New Mexico Conservancy Act. The MRGCD prepared the Official Plan of the Middle Rio Grande Conservancy District, which was filed with the District Court of the Second Judicial District of the State of New Mexico. The District Court approved the plan on August 15, 1928. The plan proposed the construction of El Vado Dam on Rio Chama, the construction of levees on both sides of the Rio Grande, a system of interior and riverside drains, four diversion dams, 168.6 miles of main canals, and 378.2 miles of laterals.

The District currently operates and maintains about 200 miles of riverside levees and about 1,100 miles of canals, laterals, wasteways, and drains.

6.3.12 Middle Rio Grande Endangered Species Collaborative Program (MRGESCP)

The MRGESCP is a partnership involving up to 20 signatories organized to protect and improve the status of endangered species along the middle Rio Grande of New Mexico while simultaneously protecting existing and future regional water uses. Signatories include Federal, State, tribal, local government, universities, and irrigation interests. Two species of particular concern to the program are the Rio Grande silvery minnow and the southwestern willow flycatcher.

6.3.13 Middle Rio Grande Pueblos

The middle Rio Grande is home to the six Indian pueblos of Cochiti, Santo Domingo, San Felipe, Santa Ana, Sandia, and Isleta. They range in size from 19,000 acres (Santa Ana) to 205,000 acres (Isleta). These pueblos, which in part are located within the Middle Rio Grande Conservancy District, were diverting water from the Rio Grande and cultivating irrigated lands long before the arrival of the Spanish in 1540. The waters of the Rio Grande also play an important role in the spiritual and ceremonial aspects of the lives of the Native Americans who reside along the river.

By the Act of March 13, 1928, Congress authorized the Secretary of the Interior to enter into a contract with the Middle Rio Grande Conservancy District that would provide for the conservation, irrigation, drainage, and flood control for the pueblo lands in the middle Rio Grande Valley. The legislation required the MRGCD to recognize a first and immemorial priority for 8,847 acres of irrigated lands, and also required the MRGCD to recognize that the water rights for reclaimed new lands are equal to those of like MRGCD lands and are to be protected from discrimination in the division and the use of water. The water rights associated with the old lands, as well as the newly reclaimed lands, are not subject to loss by nonuse or abandonment.

On June 5, 1997, the Secretaries of the U.S. Departments of Interior and Commerce issued a Secretarial Order, “American Indian Tribal Rights, Federal-Tribal Trust Responsibilities and the Endangered Species Act,” which clarifies the responsibilities of the two agencies when actions taken under the authority of the Endangered Species Act might affect Indian lands, tribal trust resources, or the exercise of American Indian tribal rights. The Order acknowledges the trust responsibility and treaty obligations of the United States toward Indian tribes and tribal members

and its government-to-government relationship in dealing with tribes. The Order provides that the Departments will carry out their responsibilities under the Endangered Species Act in a manner that harmonizes the Federal trust responsibility to tribes, tribal sovereignty, and statutory missions of the Departments, and that strives to ensure that Indian tribes do not bear a disproportionate burden for the conservation of listed species, so as to minimize the potential for conflict and confrontation.

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APPENDIX A

1994 PRESIDENTIAL MEMO: GOVERNMENT-TO-GOVERNMENT RELATIONS WITH NATIVE AMERICAN TRIBAL GOVERNMENTS

OFFICIAL AMERICAN INDIAN POLICY
The White House
Washington
April 29, 1994

MEMORANDUM FOR THE HEADS OF EXECUTIVE DEPARTMENTS AND AGENCIES

SUBJECT: Government-to-Government Relations With Native American Tribal Governments

The United States government has a unique legal relationship with Native American tribal governments as set forth in the Constitution of the United States, treaties, statutes, and court decisions. As executive departments and agencies undertake activities affecting Native American tribal rights or trust resources, such activities should be implemented in a knowledgeable, sensitive manner respectful of tribal sovereignty. Today, as part of an historic meeting, I am outlining principles that executive departments and agencies, including every component bureau and office, are to follow in their interactions with Native American tribal governments. The purpose of these principles is to clarify our responsibility to ensure that the Federal government operates within a government-to-government relationship with federally recognized Native American tribes. I am strongly committed to building a more effective day-to-day working relationship reflecting respect for the rights of self-government due the sovereign tribal governments.

In order to ensure that the rights of sovereign tribal governments are fully respected, executive branch activities shall be guided by the following:

a. The head of each executive department and agency shall be responsible for ensuring that the department or agency operates within a government-to-government relationship with federally recognized tribal governments.

b. Each executive department and agency shall consult, to the greatest extent practicable and to the extent permitted by law, with tribal governments prior to taking actions that affect federally recognized tribal governments. All such consultations are to be open and candid so that all interested parties may evaluate for themselves the potential impact of relevant proposals.

c. Each executive department and agency shall assess the impact of Federal government plans, projects, programs, and activities on tribal trust resources and assure that tribal government rights and concerns are considered during the development of such plans, projects, programs, and activities.

d. Each executive department and agency shall take appropriate steps to remove any procedural impediments to working directly and effectively with tribal governments on activities that affect the trust property and/or governmental rights of the tribes.

e. Each executive department and agency shall work cooperatively with other Federal departments and agencies to enlist their interest and support in cooperative efforts, where appropriate, to accomplish the goals of this memorandum.

f. Each executive department and agency shall apply the requirements of Executive Orders Nos. 12875 ("Enhancing the Intergovernmental Partnership") and 12866 ("Regulatory Planning and Review") to design solutions and tailor Federal programs, in appropriate circumstances, to address specific or unique needs of tribal communities.

The head of each executive department and agency shall ensure that the department or agency's bureaus and components are fully aware of this memorandum, through publication or other means, and that they are in compliance with its requirements.

This memorandum is intended only to improve the internal management of the executive branch and is not intended to, and does not, create any right to administrative or judicial review, or any other right or benefit or trust responsibility, substantive or procedural, enforceable by a party against the United States, its agencies or instrumentalities, its officers or employees, or any other person.

The Director of the Office of Management and Budget is authorized and directed to publish this memorandum in the Federal Register.

WILLIAM J. CLINTON

[FR Doc. 94-10877]

APPENDIX B

1997 SECRETARIAL ORDER #3206: AMERICAN INDIAN TRIBAL RIGHTS, FEDERAL-TRIBAL TRUST RESPONSIBILITIES, AND THE ENDANGERED SPECIES ACT

SECRETARIAL ORDER #3206

Subject: American Indian Tribal Rights, Federal-Tribal Trust Responsibilities, and the Endangered Species Act

Sec. 1. Purpose and Authority. This Order is issued by the Secretary of the Interior and the Secretary of Commerce (Secretaries) pursuant to the Endangered Species Act of 1973, 16 U.S.C. 1531, as amended (the Act), the Federal-tribal trust relationship, and other Federal law. Specifically, this Order clarifies the responsibilities of the component agencies, bureaus and offices of the Department of the Interior and the Department of Commerce (Departments), when actions taken under authority of the Act and associated implementing regulations affect, or may affect, Indian lands, tribal trust resources, or the exercise of American Indian tribal rights, as defined in this Order. This Order further acknowledges the trust responsibility and treaty obligations of the United States toward Indian tribes and tribal members and its government-to-government relationship in dealing with tribes. Accordingly, the Departments will carry out their responsibilities under the Act in a manner that harmonizes the Federal trust responsibility to tribes, tribal sovereignty, and statutory missions of the Departments, and that strives to ensure that Indian tribes do not bear a disproportionate burden for the conservation of listed species, so as to avoid or minimize the potential for conflict and confrontation.

Sec. 2. Scope and Limitations. (A) This Order is for guidance within the Departments only and is adopted pursuant to, and is consistent with, existing law.

(B) This Order shall not be construed to grant, expand, create, or diminish any legally enforceable rights, benefits or trust responsibilities, substantive or procedural, not otherwise granted or created under existing law. Nor shall this Order be construed to alter, amend, repeal, interpret or modify tribal sovereignty, any treaty rights, or other rights of any Indian tribe, or to preempt, modify or limit the exercise of any such rights.

(C) This Order does not preempt or modify the Departments' statutory authorities or the authorities of Indian tribes or the States.

(D) Nothing in this Order shall be applied to authorize direct (directed) take of listed species, or any activity that would jeopardize the continued existence of any listed species or destroy or adversely modify designated critical habitat. Incidental take issues under this Order are addressed in Principle 3(C) of Section 5.

(E) Nothing in this Order shall require additional procedural requirements for substantially completed Departmental actions, activities, or policy initiatives.

(F) Implementation of this Order shall be subject to the availability of resources and the requirements of the Anti-Deficiency Act.

(G) Should any tribe(s) and the Department(s) agree that greater efficiency in the implementation of this Order can be achieved, nothing in this Order shall prevent them from implementing strategies to do so.

(H) This Order shall not be construed to supersede, amend, or otherwise modify or affect the implementation of, existing agreements or understandings with the Departments or their agencies, bureaus, or offices including, but not limited to, memoranda of understanding, memoranda of agreement, or statements of relationship, unless mutually agreed by the signatory parties.

Sec. 3. Definitions. For the purposes of this Order, except as otherwise expressly provided, the following terms shall apply:

(A) The term "Indian tribe" shall mean any Indian tribe, band, nation, pueblo, community or other organized group within the United States which the Secretary of the Interior has identified on the most current list of tribes maintained by the Bureau of Indian Affairs.

(B) The term "tribal trust resources" means those natural resources, either on or off Indian lands, retained by, or reserved by or for Indian tribes through treaties, statutes, judicial decisions, and executive orders, which are protected by a fiduciary obligation on the part of the United States.

(C) The term "tribal rights" means those rights legally accruing to a tribe or tribes by virtue of inherent sovereign authority, unextinguished aboriginal title, treaty, statute, judicial decisions, executive order or agreement, and which give rise to legally enforceable remedies.

(D) The term "Indian lands" means any lands title to which is either: 1) held in trust by the United States for the benefit of any Indian tribe or individual; or 2) held by any Indian tribe or individual subject to restrictions by the United States against alienation.

Sec. 4. Background. The unique and distinctive political relationship between the United States and Indian tribes is defined by treaties, statutes, executive orders, judicial decisions, and agreements, and differentiates tribes from other entities that deal with, or are affected by, the Federal Government. This relationship has given rise to a special Federal trust responsibility, involving the legal responsibilities and obligations of the United States toward Indian tribes and the application of fiduciary standards of due care with respect to Indian lands, tribal trust resources, and the exercise of tribal rights.

The Departments recognize the importance of tribal self-governance and the protocols of a government-to-government relationship with Indian tribes. Long-standing Congressional and Administrative policies promote tribal self-government, self-sufficiency, and self-determination, recognizing and endorsing the fundamental rights of tribes to set their own priorities and make decisions affecting their resources and distinctive ways of life. The Departments recognize and respect, and shall consider, the value that tribal traditional knowledge provides to tribal and Federal land management decision-making and tribal resource management activities. The Departments recognize that Indian tribes are governmental sovereigns; inherent in this sovereign authority is the power to make and enforce laws, administer justice, manage and control Indian

lands, exercise tribal rights and protect tribal trust resources. The Departments shall be sensitive to the fact that Indian cultures, religions, and spirituality often involve ceremonial and medicinal uses of plants, animals, and specific geographic places.

Indian lands are not Federal public lands or part of the public domain, and are not subject to Federal public land laws. They were retained by tribes or were set aside for tribal use pursuant to treaties, statutes, judicial decisions, executive orders or agreements. These lands are managed by Indian tribes in accordance with tribal goals and objectives, within the framework of applicable laws.

Because of the unique government-to-government relationship between Indian tribes and the United States, the Departments and affected Indian tribes need to establish and maintain effective working relationships and mutual partnerships to promote the conservation of sensitive species (including candidate, proposed and listed species) and the health of ecosystems upon which they depend. Such relationships should focus on cooperative assistance, consultation, the sharing of information, and the creation of government-to-government partnerships to promote healthy ecosystems.

In facilitating a government-to-government relationship, the Departments may work with intertribal organizations, to the extent such organizations are authorized by their member tribes to carry out resource management responsibilities.

Sec. 5. Responsibilities. To achieve the objectives of this Order, the heads of all agencies, bureaus and offices within the Department of the Interior, and the Administrator of the National Oceanic and Atmospheric Administration (NOAA) within the Department of Commerce, shall be responsible for ensuring that the following directives are followed:

Principle 1. THE DEPARTMENTS SHALL WORK DIRECTLY WITH INDIAN TRIBES ON A GOVERNMENT-TO-GOVERNMENT BASIS TO PROMOTE HEALTHY ECOSYSTEMS.

The Departments shall recognize the unique and distinctive political and constitutionally based relationship that exists between the United States and each Indian tribe, and shall view tribal governments as sovereign entities with authority and responsibility for the health and welfare of ecosystems on Indian lands. The Departments recognize that Indian tribes are governmental sovereigns with inherent powers to make and enforce laws, administer justice, and manage and control their natural resources. Accordingly, the Departments shall seek to establish effective government-to-government working relationships with tribes to achieve the common goal of promoting and protecting the health of these ecosystems. Whenever the agencies, bureaus, and offices of the Departments are aware that their actions planned under the Act may impact tribal trust resources, the exercise of tribal rights, or Indian lands, they shall consult with, and seek the participation of, the affected Indian tribes to the maximum extent practicable. This shall include providing affected tribes adequate opportunities to participate in data collection, consensus seeking, and associated processes. To facilitate the government-to-government relationship, the Departments may coordinate their discussions with a representative from an intertribal organization, if so designated by the affected tribe(s).

Except when determined necessary for investigative or prosecutorial law enforcement activities, or when otherwise provided in a Federal-tribal agreement, the Departments, to the maximum extent practicable, shall obtain permission from tribes before knowingly entering Indian reservations and tribally-owned fee lands for purposes of ESA-related activities, and shall communicate as necessary with the appropriate tribal officials. If a tribe believes this section has been violated, such tribe may file a complaint with the appropriate Secretary, who shall promptly investigate and respond to the tribe.

Principle 2. THE DEPARTMENTS SHALL RECOGNIZE THAT INDIAN LANDS ARE NOT SUBJECT TO THE SAME CONTROLS AS FEDERAL PUBLIC LANDS.

The Departments recognize that Indian lands, whether held in trust by the United States for the use and benefit of Indians or owned exclusively by an Indian tribe, are not subject to the controls or restrictions set forth in Federal public land laws. Indian lands are not Federal public lands or part of the public domain, but are rather retained by tribes or set aside for tribal use pursuant to treaties, statutes, court orders, executive orders, judicial decisions, or agreements. Accordingly, Indian tribes manage Indian lands in accordance with tribal goals and objectives, within the framework of applicable laws.

Principle 3. THE DEPARTMENTS SHALL ASSIST INDIAN TRIBES IN DEVELOPING AND EXPANDING TRIBAL PROGRAMS SO THAT HEALTHY ECOSYSTEMS ARE PROMOTED AND CONSERVATION RESTRICTIONS ARE UNNECESSARY.

(A) The Departments shall take affirmative steps to assist Indian tribes in developing and expanding tribal programs that promote healthy ecosystems. The Departments shall take affirmative steps to achieve the common goals of promoting healthy ecosystems, Indian self-government, and productive government-to-government relationships under this Order, by assisting Indian tribes in developing and expanding tribal programs that promote the health of ecosystems upon which sensitive species (including candidate, proposed and listed species) depend.

The Departments shall offer and provide such scientific and technical assistance and information as may be available for the development of tribal conservation and management plans to promote the maintenance, restoration, enhancement and health of the ecosystems upon which sensitive species (including candidate, proposed, and listed species) depend, including the cooperative identification of appropriate management measures to address concerns for such species and their habitats.

(B) The Departments shall recognize that Indian tribes are appropriate governmental entities to manage their lands and tribal trust resources. The Departments acknowledge that Indian tribes value, and exercise responsibilities for, management of Indian lands and tribal trust resources. In keeping with the Federal policy of promoting tribal self-government, the Departments shall respect the exercise of tribal sovereignty over the management of Indian lands, and tribal trust resources. Accordingly, the Departments shall give deference to tribal conservation and management plans for tribal trust resources that: (a) govern activities on Indian lands, including, for the purposes of this section, tribally-owned fee lands, and (b) address the conservation needs of listed species. The Departments shall conduct government-to-government consultations to discuss the extent to which tribal resource management plans for tribal trust

resources outside Indian lands can be incorporated into actions to address the conservation needs of listed species.

(C) The Departments, as trustees, shall support tribal measures that preclude the need for conservation restrictions.

At the earliest indication that the need for Federal conservation restrictions is being considered for any species, the Departments, acting in their trustee capacities, shall promptly notify all potentially affected tribes, and provide such technical, financial, or other assistance as may be appropriate, thereby assisting Indian tribes in identifying and implementing tribal conservation and other measures necessary to protect such species.

In the event that the Departments determine that conservation restrictions are necessary in order to protect listed species, the Departments, in keeping with the trust responsibility and government-to-government relationships, shall consult with affected tribes and provide written notice to them of the intended restriction as far in advance as practicable. If the proposed conservation restriction is directed at a tribal activity that could raise the potential issue of direct (directed) take under the Act, then meaningful government-to-government consultation shall occur, in order to strive to harmonize the Federal trust responsibility to tribes, tribal sovereignty and the statutory missions of the Departments. In cases involving an activity that could raise the potential issue of an incidental take under the Act, such notice shall include an analysis and determination that all of the following conservation standards have been met: (i) the restriction is reasonable and necessary for conservation of the species at issue; (ii) the conservation purpose of the restriction cannot be achieved by reasonable regulation of non-Indian activities; (iii) the measure is the least restrictive alternative available to achieve the required conservation purpose; (iv) the restriction does not discriminate against Indian activities, either as stated or applied; and, (v) voluntary tribal measures are not adequate to achieve the necessary conservation purpose.

Principle 4. THE DEPARTMENTS SHALL BE SENSITIVE TO INDIAN CULTURE, RELIGION AND SPIRITUALITY.

The Departments shall take into consideration the impacts of their actions and policies under the Act on Indian use of listed species for cultural and religious purposes. The Departments shall avoid or minimize, to the extent practicable, adverse effects upon the noncommercial use of listed sacred plants and animals in medicinal treatments and in the expression of cultural and religious beliefs by Indian tribes. When appropriate, the Departments may issue guidelines to accommodate Indian access to, and traditional uses of, listed species, and to address unique circumstances that may exist when administering the Act.

Principle 5. THE DEPARTMENTS SHALL MAKE AVAILABLE TO INDIAN TRIBES INFORMATION RELATED TO TRIBAL TRUST RESOURCES AND INDIAN LANDS, AND, TO FACILITATE THE MUTUAL EXCHANGE OF INFORMATION, SHALL STRIVE TO PROTECT SENSITIVE TRIBAL INFORMATION FROM DISCLOSURE.

To further tribal self-government and the promotion of healthy ecosystems, the Departments recognize the critical need for Indian tribes to possess complete and accurate information related to Indian lands and tribal trust resources. To the extent consistent with the provisions of the Privacy Act, the Freedom of Information Act (FOIA) and the Departments' abilities to continue

to assert FOIA exemptions with regard to FOIA requests, the Departments shall make available to an Indian tribe all information held by the Departments which is related to its Indian lands and tribal trust resources. In the course of the mutual exchange of information, the Departments shall protect, to the maximum extent practicable, tribal information which has been disclosed to or collected by the Departments. The Departments shall promptly notify and, when appropriate, consult with affected tribes regarding all requests for tribal information relating to the administration of the Act.

Sec. 6. Federal-Tribal Intergovernmental Agreements. The Departments shall, when appropriate and at the request of an Indian tribe, pursue intergovernmental agreements to formalize arrangements involving sensitive species (including candidate, proposed, and listed species) such as, but not limited to, land and resource management, multi-jurisdictional partnerships, cooperative law enforcement, and guidelines to accommodate Indian access to, and traditional uses of, natural products. Such agreements shall strive to establish partnerships that harmonize the Departments' missions under the Act with the Indian tribe's own ecosystem management objectives.

Sec. 7. Alaska. The Departments recognize that section 10(e) of the Act governs the taking of listed species by Alaska Natives for subsistence purposes and that there is a need to study the implementation of the Act as applied to Alaska tribes and natives. Accordingly, this Order shall not apply to Alaska and the Departments shall, within one year of the date of this Order, develop recommendations to the Secretaries to supplement or modify this Order and its Appendix, so as to guide the administration of the Act in Alaska. These recommendations shall be developed with the full cooperation and participation of Alaska tribes and natives. The purpose of these recommendations shall be to harmonize the government-to-government relationship with Alaska tribes, the Federal trust responsibility to Alaska tribes and Alaska Natives, the rights of Alaska Natives, and the statutory missions of the Departments.

Sec. 8. Special Study on Cultural and Religious Use of Natural Products. The Departments recognize that there remain tribal concerns regarding the access to, and uses of, eagle feathers, animal parts, and other natural products for Indian cultural and religious purposes. Therefore, the Departments shall work together with Indian tribes to develop recommendations to the Secretaries within one year to revise or establish uniform administrative procedures to govern the possession, distribution, and transportation of such natural products that are under Federal jurisdiction or control.

Sec. 9. Dispute Resolution. (A) Federal-tribal disputes regarding implementation of this Order shall be addressed through government-to-government discourse. Such discourse is to be respectful of government-to-government relationships and relevant Federal-tribal agreements, treaties, judicial decisions, and policies pertaining to Indian tribes. Alternative dispute resolution processes may be employed as necessary to resolve disputes on technical or policy issues within statutory time frames; provided that such alternative dispute resolution processes are not intended to apply in the context of investigative or prosecutorial law enforcement activities.

(B) Questions and concerns on matters relating to the use or possession of listed plants or listed animal parts used for religious or cultural purposes shall be referred to the appropriate Departmental officials and the appropriate tribal contacts for religious and cultural affairs.

Sec. 10. Implementation. This Order shall be implemented by all agencies, bureaus, and offices of the Departments, as applicable. In addition, the U.S. Fish and Wildlife Service and the National Marine Fisheries Service shall implement their specific responsibilities under the Act in accordance with the guidance contained in the attached Appendix.

Sec. 11. Effective Date. This Order, issued within the Department of the Interior as Order No. 3206, is effective immediately and will remain in effect until amended, superseded, or revoked.

This Secretarial Order, entitled "American Indian Tribal Rights, Federal-Tribal Trust Responsibilities, and the Endangered Species Act," and its accompanying Appendix were issued this 5th day of June, 1997, in Washington, D.C., by the Secretary of the Interior and the Secretary of Commerce.

_____

Secretary of the Interior
Secretary of Commerce

Date: June 5, 1997

APPENDIX

Appendix to Secretarial Order issued within the Department of the Interior as Order No. 3206

Sec. 1. Purpose. The purpose of this Appendix is to provide policy to the National, regional and field offices of the U.S. Fish and Wildlife Service (FWS) and the National Marine Fisheries Service (NMFS), (hereinafter "Services"), concerning the implementation of the Secretarial Order issued by the Department of the Interior and the Department of Commerce, entitled "American Indian Tribal Rights, Federal-Tribal Trust Responsibilities, and the Endangered Species Act." This policy furthers the objectives of the FWS Native American Policy (June 28, 1994), and the American Indian and Alaska Native Policy of the Department of Commerce (March 30, 1995). This Appendix shall be considered an integral part of the above Secretarial Order, and all sections of the Order shall apply in their entirety to this Appendix.

Sec. 2. General Policy. (A) Goals. The goals of this Appendix are to provide a basis for administration of the Act in a manner that (1) recognizes common Federal-tribal goals of conserving sensitive species (including candidate, proposed, and listed species) and the ecosystems upon which they depend, Indian self-government, and productive government-to-government relationships; and (2) harmonizes the Federal trust responsibility to tribes, tribal sovereignty, and the statutory missions of the Departments, so as to avoid or minimize the potential for conflict and confrontation.

(B) Government-to-Government Communication. It shall be the responsibility of each Service's regional and field offices to maintain a current list of tribal contact persons within each Region, and to ensure that meaningful government-to-government communication occurs regarding actions to be taken under the Act.

(C) Agency Coordination. The Services have the lead roles and responsibilities in administering the Act, while the Services and other Federal agencies share responsibilities for honoring Indian treaties and other sources of tribal rights. The Bureau of Indian Affairs (BIA) has the primary responsibility for carrying out the Federal responsibility to administer tribal trust property and represent tribal interests during formal section 7 consultations under the Act. Accordingly, the Services shall consult, as appropriate, with each other, affected Indian tribes, the BIA, the Office of the Solicitor (Interior), the Office of American Indian Trust (Interior), and the NOAA Office of General Counsel in determining how the fiduciary responsibility of the Federal government to Indian tribes may best be realized.

(D) Technical Assistance. In their roles as trustees, the Services shall offer and provide technical assistance and information for the development of tribal conservation and management plans to promote the maintenance, restoration, and enhancement of the ecosystems on which sensitive species (including candidate, proposed, and listed species) depend. The Services should be creative in working with the tribes to accomplish these objectives. Such technical assistance may include the cooperative identification of appropriate management measures to address concerns for sensitive species (including candidate, proposed and listed species) and their habitats. Such cooperation may include intergovernmental agreements to enable Indian tribes to more fully participate in conservation programs under the Act. Moreover, the Services may enter into conservation easements with tribal governments and enlist tribal participation in incentive programs.

(E) Tribal Conservation Measures. The Services shall, upon the request of an Indian tribe or the BIA, cooperatively review and assess tribal conservation measures for sensitive species (including candidate, proposed and listed species) which may be included in tribal resource management plans. The Services will communicate to the tribal government their desired conservation goals and objectives, as well as any technical advice or suggestions for the modification of the plan to enhance its benefits for the conservation of sensitive species (including candidate, proposed and listed species). In keeping with the Services' initiatives to promote voluntary conservation partnerships for listed species and the ecosystems upon which they depend, the Services shall consult on a government-to-government basis with the affected tribe to determine and provide appropriate assurances that would otherwise be provided to a non-Indian.

Sec. 3. The Federal Trust Responsibility and the Administration of the Act.

The Services shall coordinate with affected Indian tribes in order to fulfill the Services' trust responsibilities and encourage meaningful tribal participation in the following programs under the Act, and shall:

(A) Candidate Conservation.

(1) Solicit and utilize the expertise of affected Indian tribes in evaluating which animal and plant species should be included on the list of candidate species, including conducting population status inventories and geographical distribution surveys;

(2) Solicit and utilize the expertise of affected Indian tribes when designing and implementing candidate conservation actions to remove or alleviate threats so that the species' listing priority is reduced or listing as endangered or threatened is rendered unnecessary; and

(3) Provide technical advice and information to support tribal efforts and facilitate voluntary tribal participation in implementation measures to conserve candidate species on Indian lands.

(B) The Listing Process.

(1) Provide affected Indian tribes with timely notification of the receipt of petitions to list species, the listing of which could affect the exercise of tribal rights or the use of tribal trust resources. In addition, the Services shall solicit and utilize the expertise of affected Indian tribes in responding to listing petitions that may affect tribal trust resources or the exercise of tribal rights.

(2) Recognize the right of Indian tribes to participate fully in the listing process by providing timely notification to, soliciting information and comments from, and utilizing the expertise of, Indian tribes whose exercise of tribal rights or tribal trust resources could be affected by a particular listing. This process shall apply to proposed and final rules to: (i) list species as endangered or threatened; (ii) designate critical habitat; (iii) reclassify a species from endangered to threatened (or vice versa); (iv) remove a species from the list; and (v) designate experimental populations.

(3) Recognize the contribution to be made by affected Indian tribes, throughout the process and prior to finalization and close of the public comment period, in the review of proposals to designate critical habitat and evaluate economic impacts of such proposals with implications for tribal trust resources or the exercise of tribal rights. The Services shall notify affected Indian tribes and the BIA, and solicit information on, but not limited to, tribal cultural values, reserved hunting, fishing, gathering, and other Indian rights or tribal economic development, for use in: (i) the preparation of economic analyses involving impacts on tribal communities; and (ii) the preparation of "balancing tests" to determine appropriate exclusions from critical habitat and in the review of comments or petitions concerning critical habitat that may adversely affect the rights or resources of Indian tribes.

(4) In keeping with the trust responsibility, shall consult with the affected Indian tribe(s) when considering the designation of critical habitat in an area that may impact tribal trust resources, tribally-owned fee lands, or the exercise of tribal rights. Critical habitat shall not be designated in such areas unless it is determined essential to conserve a listed species. In designating critical habitat, the Services shall evaluate and document the extent to which the conservation needs of the listed species can be achieved by limiting the designation to other lands.

(5) When exercising regulatory authority for threatened species under section 4(d) of the Act, avoid or minimize effects on tribal management or economic development, or the exercise of reserved Indian fishing, hunting, gathering, or other rights, to the maximum extent allowed by law.

(6) Having first provided the affected Indian tribe(s) the opportunity to actively review and comment on proposed listing actions, provide affected Indian tribe(s) with a written explanation whenever a final decision on any of the following activities conflicts with comments provided by

an affected Indian tribe: (i) list a species as endangered or threatened; (ii) designate critical habitat; (iii) reclassify a species from endangered to threatened (or vice versa); (iv) remove a species from the list; or (v) designate experimental populations. If an affected Indian tribe petitions for rulemaking under Section 4(b)(3), the Services will consult with and provide a written explanation to the affected tribe if they fail to adopt the requested regulation.

(C) ESA Section 7 Consultation.

(1) Facilitate the Services' use of the best available scientific and commercial data by soliciting information, traditional knowledge, and comments from, and utilizing the expertise of, affected Indian tribes in addition to data provided by the action agency during the consultation process. The Services shall provide timely notification to affected tribes as soon as the Services are aware that a proposed Federal agency action subject to formal consultation may affect tribal rights or tribal trust resources.

(2) Provide copies of applicable final biological opinions to affected tribes to the maximum extent permissible by law.

(3)(a) When the Services enter formal consultation on an action proposed by the BIA, the Services shall consider and treat affected tribes as license or permit applicants entitled to full participation in the consultation process. This shall include, but is not limited to, invitations to meetings between the Services and the BIA, opportunities to provide pertinent scientific data and to review data in the administrative record, and to review biological assessments and draft biological opinions. In keeping with the trust responsibility, tribal conservation and management plans for tribal trust resources that govern activities on Indian lands, including for purposes of this paragraph, tribally-owned fee lands, shall serve as the basis for developing any reasonable and prudent alternatives, to the extent practicable.

(b) When the Services enter into formal consultations with an Interior Department agency other than the BIA, or an agency of the Department of Commerce, on a proposed action which may affect tribal rights or tribal trust resources, the Services shall notify the affected Indian tribe(s) and provide for the participation of the BIA in the consultation process.

(c) When the Services enter into formal consultations with agencies not in the Departments of the Interior or Commerce, on a proposed action which may affect tribal rights or tribal trust resources, the Services shall notify the affected Indian tribe(s) and encourage the action agency to invite the affected tribe(s) and the BIA to participate in the consultation process.

(d) In developing reasonable and prudent alternatives, the Services shall give full consideration to all comments and information received from any affected tribe, and shall strive to ensure that any alternative selected does not discriminate against such tribe(s). The Services shall make a written determination describing (i) how the selected alternative is consistent with their trust responsibilities, and (ii) the extent to which tribal conservation and management plans for affected tribal trust resources can be incorporated into any such alternative.

(D) Habitat Conservation Planning.

(1) Facilitate the Services' use of the best available scientific and commercial data by soliciting information, traditional knowledge, and comments from, and utilizing the expertise of, affected

tribal governments in habitat conservation planning that may affect tribal trust resources or the exercise of tribal rights. The Services shall facilitate tribal participation by providing timely notification as soon as the Services are aware that a draft Habitat Conservation Plan (HCP) may affect such resources or the exercise of such rights.

(2) Encourage HCP applicants to recognize the benefits of working cooperatively with affected Indian tribes and advocate for tribal participation in the development of HCPs. In those instances where permit applicants choose not to invite affected tribes to participate in those negotiations, the Services shall consult with the affected tribes to evaluate the effects of the proposed HCP on tribal trust resources and will provide the information resulting from such consultation to the HCP applicant prior to the submission of the draft HCP for public comment. After consultation with the tribes and the non-Federal landowner and after careful consideration of the tribe's concerns, the Services must clearly state the rationale for the recommended final decision and explain how the decision relates to the Services' trust responsibility.

(3) Advocate the incorporation of measures into HCPs that will restore or enhance tribal trust resources. The Services shall advocate for HCP provisions that eliminate or minimize the diminishment of tribal trust resources. The Services shall be cognizant of the impacts of measures incorporated into HCPs on tribal trust resources and the tribal ability to utilize such resources.

(4) Advocate and encourage early participation by affected tribal governments in the development of region-wide or state-wide habitat conservation planning efforts and in the development of any related implementation documents.

(E) Recovery.

(1) Solicit and utilize the expertise of affected Indian tribes by having tribal representation, as appropriate, on recovery teams when the species occurs on Indian lands (including tribally-owned fee lands), affects tribal trust resources, or affects the exercise of tribal rights.

(2) In recognition of tribal rights, cooperate with affected tribes to develop and implement recovery plans in a manner that minimizes the social, cultural and economic impacts on tribal communities, consistent with the timely recovery of listed species. The Services shall be cognizant of tribal desires to attain population levels and conditions that are sufficient to support the meaningful exercise of reserved rights and the protection of tribal management or development prerogatives for Indian resources.

(3) Invite affected Indian tribes, or their designated representatives, to participate in the recovery plan implementation process through the development of a participation plan and through tribally-designated membership on recovery teams. The Services shall work cooperatively with affected Indian tribes to identify and implement the most effective measures to speed the recovery process.

(4) Solicit and utilize the expertise of affected Indian tribes in the design of monitoring programs for listed species and for species which have been removed from the list of *Endangered and Threatened Wildlife and Plants* occurring on Indian lands or affecting the exercise of tribal rights or tribal trust resources.

(F) Law Enforcement.

(1) At the request of an Indian tribe, enter into cooperative law enforcement agreements as integral components of tribal, Federal, and State efforts to conserve species and the ecosystems upon which they depend. Such agreements may include the delegation of enforcement authority under the Act, within limitations, to full-time tribal conservation law enforcement officers.

(2) Cooperate with Indian tribes in enforcement of the Act by identifying opportunities for joint enforcement operations or investigations. Discuss new techniques and methods for the detection and apprehension of violators of the Act or tribal conservation laws, and exchange law enforcement information in general.

APPENDIX C

2000 EXECUTIVE ORDER 13175: CONSULTATION AND COORDINATION WITH INDIAN TRIBAL GOVERNMENTS

Executive Order 13175 of November 6, 2000

Consultation and Coordination With Indian Tribal Governments

By the authority vested in me as President by the Constitution and the laws of the United States of America, and in order to establish regular and meaningful consultation and collaboration with tribal officials in the development of Federal policies that have tribal implications, to strengthen the United States government-to-government relationships with Indian tribes, and to reduce the imposition of unfunded mandates upon Indian tribes; it is hereby ordered as follows:

Section 1. Definitions. For purposes of this order:

a. "Policies that have tribal implications" refers to regulations, legislative comments or proposed legislation, and other policy statements or actions that have substantial direct effects on one or more Indian tribes, on the relationship between the Federal government and Indian tribes, or on the distribution of power and responsibilities between the Federal government and Indian tribes.

b. "Indian tribe" means an Indian or Alaska Native tribe, band, nation, pueblo, village, or community that the Secretary of the Interior acknowledges to exist as an Indian tribe pursuant to the federally Recognized Indian Tribe List Act of 1994, 25 U.S.C. 479a.

c. "Agency" means any authority of the United States that is an "agency" under 44 U.S.C. 3502(1), other than those considered to be independent regulatory agencies, as defined in 44 U.S.C. 3502(5).

d. "Tribal officials" means elected or duly appointed officials of Indian tribal governments or authorized intertribal organizations.

Sec. 2. Fundamental Principles. In formulating or implementing policies that have tribal implications, agencies shall be guided by the following fundamental principles:

a. The United States has a unique legal relationship with Indian tribal governments as set forth in the Constitution of the United States, treaties, statutes, Executive Orders, and court decisions. Since the formation of the Union, the United States has recognized Indian tribes as domestic dependent nations under its protection. The Federal government has enacted numerous statutes and promulgated numerous regulations that establish and define a trust relationship with Indian tribes.

b. Our Nation, under the law of the United States, in accordance with treaties, statutes, Executive Orders, and judicial decisions, has recognized the right of Indian tribes to self-

government. As domestic dependent nations, Indian tribes exercise inherent sovereign powers over their members and territory. The United States continues to work with Indian tribes on a government-to-government basis to address issues concerning Indian tribal self-government, tribal trust resources, and Indian tribal treaty and other rights.

c. The United States recognizes the right of Indian tribes to self-government and supports tribal sovereignty and self-determination.

Sec. 3. Policymaking Criteria. In addition to adhering to the fundamental principles set forth in section 2, agencies shall adhere, to the extent permitted by law, to the following criteria when formulating and implementing policies that have tribal implications:

a. Agencies shall respect Indian tribal self-government and sovereignty, honor tribal treaty and other rights, and strive to meet the responsibilities that arise from the unique legal relationship between the Federal government and Indian tribal governments.

b. With respect to Federal statutes and regulations administered by Indian tribal governments, the Federal government shall grant Indian tribal governments the maximum administrative discretion possible.

c. When undertaking to formulate and implement policies that have tribal implications, agencies shall:

    1. encourage Indian tribes to develop their own policies to achieve program objectives;

    2. where possible, defer to Indian tribes to establish standards; and

    3. in determining whether to establish Federal standards, consult with tribal officials as to the need for Federal standards and any alternatives that would limit the scope of Federal standards or otherwise preserve the prerogatives and authority of Indian tribes.

Sec. 4. Special Requirements for Legislative Proposals. Agencies shall not submit to the Congress legislation that would be inconsistent with the policymaking criteria in Section 3.

Sec. 5. Consultation.

a. Each agency shall have an accountable process to ensure meaningful and timely input by tribal officials in the development of regulatory policies that have tribal implications. Within 30 days after the effective date of this order, the head of each agency shall designate an official with principal responsibility for the agency's implementation of this order. Within 60 days of the effective date of this order, the designated official shall submit to the Office of Management and Budget (OMB) a description of the agency's consultation process.

b. To the extent practicable and permitted by law, no agency shall promulgate any regulation that has tribal implications, that imposes substantial direct compliance costs on Indian tribal governments, and that is not required by statute, unless:

1. funds necessary to pay the direct costs incurred by the Indian tribal government or the tribe in complying with the regulation are provided by the Federal government; or

2. the agency, prior to the formal promulgation of the regulation,

   A. consulted with tribal officials early in the process of developing the proposed regulation;

   B. in a separately identified portion of the preamble to the regulation as it is to be issued in the Federal Register, provides to the Director of OMB a tribal summary impact statement, which consists of a description of the extent of the agency's prior consultation with tribal officials, a summary of the nature of their concerns and the agency's position supporting the need to issue the regulation, and a statement of the extent to which the concerns of tribal officials have been met; and

   C. makes available to the Director of OMB any written communications submitted to the agency by tribal officials.

c. To the extent practicable and permitted by law, no agency shall promulgate any regulation that has tribal implications and that preempts tribal law unless the agency, prior to the formal promulgation of the regulation,

   1. consulted with tribal officials early in the process of developing the proposed regulation;

   2. in a separately identified portion of the preamble to the regulation as it is to be issued in the Federal Register, provides to the Director of OMB a tribal summary impact statement, which consists of a description of the extent of the agency's prior consultation with tribal officials, a summary of the nature of their concerns and the agency's position supporting the need to issue the regulation, and a statement of the extent to which the concerns of tribal officials have been met; and

   3. makes available to the Director of OMB any written communications submitted to the agency by tribal officials.

d. On issues relating to tribal self-government, tribal trust resources, or Indian tribal treaty and other rights, each agency should explore and, where appropriate, use consensual mechanisms for developing regulations, including negotiated rulemaking.

Sec. 6. Increasing Flexibility for Indian Tribal Waivers.

a. Agencies shall review the processes under which Indian tribes apply for waivers of statutory and regulatory requirements and take appropriate steps to streamline those processes.

b. Each agency shall, to the extent practicable and permitted by law, consider any application by an Indian tribe for a waiver of statutory or regulatory requirements in

connection with any program administered by the agency with a general view toward increasing opportunities for utilizing flexible policy approaches at the Indian tribal level in cases in which the proposed waiver is consistent with the applicable Federal policy objectives and is otherwise appropriate.

c. Each agency shall, to the extent practicable and permitted by law, render a decision upon a complete application for a waiver within 120 days of receipt of such application by the agency, or as otherwise provided by law or regulation. If the application for waiver is not granted, the agency shall provide the applicant with timely written notice of the decision and the reasons therefore.

d. This section applies only to statutory or regulatory requirements that are discretionary and subject to waiver by the agency.

Sec. 7. Accountability.

a. In transmitting any draft final regulation that has tribal implications to OMB pursuant to Executive Order 12866 of September 30, 1993, each agency shall include a certification from the official designated to ensure compliance with this order stating that the requirements of this order have been met in a meaningful and timely manner.

b. In transmitting proposed legislation that has tribal implications to OMB, each agency shall include a certification from the official designated to ensure compliance with this order that all relevant requirements of this order have been met.

c. Within 180 days after the effective date of this order the Director of OMB and the Assistant to the President for Intergovernmental Affairs shall confer with tribal officials to ensure that this order is being properly and effectively implemented.

Sec. 8. Independent Agencies. Independent regulatory agencies are encouraged to comply with the provisions of this order.

Sec. 9. General Provisions.

a. This order shall supplement but not supersede the requirements contained in Executive Order 12866 (Regulatory Planning and Review), Executive Order 12988 (Civil Justice Reform), OMB Circular A-19, and the Executive Memorandum of April 29, 1994, on Government-to-Government Relations with Native American Tribal Governments.

b. This order shall complement the consultation and waiver provisions in sections 6 and 7 of Executive Order 13132 (Federalism).

c. Executive Order 13084 (Consultation and Coordination with Indian Tribal Governments) is revoked at the time this order takes effect.

d. This order shall be effective 60 days after the date of this order.

Sec. 10. Judicial Review. This order is intended only to improve the internal management of the executive branch, and is not intended to create any right, benefit, or trust responsibility, substantive or procedural, enforceable at law by a party against the United States, its agencies, or

any person.

(Presidential Sig.)

THE WHITE HOUSE, November 6, 2000.

APPENDIX D

2004 PRESIDENTIAL MEMORANDUM: GOVERNMENT-TO-GOVERNMENT RELATIONSHIP WITH TRIBAL GOVERNMENTS

The White House
Washington
September 23, 2004

Memorandum for the Heads of Executive Departments and Agencies
Government-to-Government Relationship with Tribal Governments

The United States has a unique legal and political relationship with Indian tribes and a special relationship with Alaska Native entities as provided in the Constitution of the United States, treaties, and Federal statutes. Presidents for decades have recognized this relationship. President Nixon announced a national policy of self-determination for Indian tribes in 1970. More recently, Executive Order 13175, entitled Consultation and Coordination with Indian Tribal Governments, was issued in 2000. I reiterated my Administration's adherence to a government-to-government relationship and support for tribal sovereignty and self-determination earlier this year in Executive Order 13336, entitled American Indian and Alaska Native Education.

My Administration is committed to continuing to work with federally recognized tribal governments on a government-to-government basis and strongly supports and respects tribal sovereignty and self-determination for tribal governments in the United States. I take pride in acknowledging and reaffirming the existence and durability of our unique government-to-government relationship and these abiding principles.

This commitment begins at the White House, where my Director of Intergovernmental Affairs serves as my White House liaison with all Indian nations and works with fly recognized tribal governments on an intergovernmental basis. Moreover, it is critical that all departments and agencies adhere to these principles and work with tribal governments in a manner that cultivates mutual respect and fosters greater understanding to reinforce these principles.

Accordingly, the head of each executive department and agency (agency) shall continue to ensure to the greatest extent practicable and as permitted by United States law that the agency's working relationship with federally recognized tribal governments fully respects the rights of self-government and self-determination due tribal governments. Department or agency inquiries regarding this memorandum, specifically those related to regulatory, legislative, or budgetary issues, should be directed to the Office of Management and Budget.

This memorandum is intended only to improve the internal management of the executive branch and is not intended to, and does not, create any right, benefit, or trust responsibility, substantive or procedural, enforceable at law or in equity, by a party against the United States, its agencies, entities, or instrumentalities, its officers or employees, or any other person.

GEORGE W. BUSH

APPENDIX E

Middle Rio Grande Long-Term Fish Population Monitoring Program

The following describes the population monitoring sampling protocol that has been used in recent years in the middle Rio Grande to monitor Rio Grande silvery minnow populations. This protocol is to be used to assess whether future Rio Grande silvery minnow populations meet the recovery objectives and criteria outlined in this recovery plan.

A total of 20 sampling sites have been monitored monthly to assess general trends in abundance, distribution, and composition of middle Rio Grande fishes, including Rio Grande silvery minnow, over time (Dudley et al. 2005). The Angostura Reach has five sampling localities, the Isleta Reach has six, and the San Acacia Reach has nine. The 20 sampling sites in the middle Rio Grande overlap the current range of Rio Grande silvery minnow. Sites were chosen based on access.

Sampling sites were chosen from more than 100 possibilities, based on a variety of factors, including access, land ownership, spatial location within reaches and between reaches, and overall suitability for effective and efficient sampling. Most have been sampled consistently since 1993, although several sites were added over time to increase the spatial extent of sampling (e.g., Angostura Diversion Dam, Isleta Reach area, and downstream of the San Marcial railroad bridge). Also, the temporal frequency of monitoring has increased from quarterly (1993-1997), to bimonthly (1999-2001), to monthly (2002-2005).

Fish are collected by rapidly drawing a two-person 3.1 m (wide) x 1.8 m (high) small mesh (ca. 5 mm) seine through discrete mesohabitats. The effective width of the seine during active sampling was 2.5 m. During spring and summer, a 1.0 m x 1.0 m fine mesh (ca. 1.5 mm) seine is used to selectively sample shallow, low velocity habitats for larval fish. The total length of each sampling site is 200 m upstream to downstream. A total of about 15-20 seine hauls (median=17 seine hauls) are typically made at each sampling site unless conditions do not permit this (i.e., extremely high discharge or lack of flow). Each mesohabitat type (see Dudley et al. 2005 for definitions) present at the site (e.g., main channel pool, backwater, riffle, side channel run, etc.) is sampled. There are usually about 5-10 mesohabitat types present at a site. The total length of each seine haul varies, based on the size and availability of mesohabitats (i.e., some mesohabitats, like backwaters, are small or absent) but is generally about 15 m. Overall sampling area per site is about 600 m^2. Similar mesohabitat locations are sampled within a site during monthly monitoring efforts, with the exception of during extremely high or low discharge periods. The percent allocation of sampling effort (by mesohabitat type) is approximately equal among reaches (Dudley et al. 2005). Catch-per-unit-effort (CPUE) is calculated as the total number (#) of fish collected · area sampled^{-1} · 100 (i.e., N [fish] · effective seine width [m^{-1}] · haul length [m^{-1}] · 100), to yield #/100m^2. Isolated pools are not included in the calculation of CPUE as fish are artificially concentrated in these areas.

Annual reproduction is documented using an egg collecting device (Moore Egg Collector, MEC) developed specifically for the collection of large numbers of live and undamaged semibuoyant fish eggs (Altenbach et al. 2000). Catch rate of Rio Grande silvery minnow eggs in the middle

Rio Grande is determined following the sampling protocol described in Altenbach et al. (2000). A mechanical flow-meter is attached to the MEC so that volume of water filtered can be calculated and catch rate per unit of water determined. The CPUE of drifting eggs is calculated as the total number of eggs collected · volume of water sampled^{-1} · 100 (i.e., N [eggs] · m^3 water^{-1} · 100), to yield #/100m^3.

Previous studies have demonstrated May and June as the primary period of Rio Grande silvery minnow spawning activity. The normal sampling regime is comprised of three daily efforts (morning, noon, and evening), each of two-hour duration. Two MECs are operated simultaneously to increase the volume of water and number of eggs sampled per unit of time.

References

Altenbach, C.S., Dudley, R.K., and S.P. Platania. 2000. A new device for collecting drifting semibuoyant fish eggs. Transactions of the American Fisheries Society 129:296-300.

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APPENDIX F

RIO GRANDE AND PECOS RIVER: REACH-BY-REACH ANALYSIS OF POTENTIAL FOR REESTABLISHMENT OF RIO GRANDE SILVERY MINNOW

Reach-By-Reach Analysis and Reestablishment Site Selection Process

The recovery team undertook a reach-by-reach analysis of the Rio Grande and Pecos River basins to identify the salient hydrological, chemical, and biological features of each reach, to address the threats to the Rio Grande silvery minnow, and to consider the suitability of each reach for the potential for reestablishment. The analysis of each reach is based not upon detailed investigations made by the recovery team, but upon the combined experience and observations of the team members and evaluation and consideration of research that has been completed.

Identification of the river reaches proposed for recovery was based upon the presence of dams (upstream) and reservoirs (downstream), with the intervening sections being conterminous. In such reaches, the potential for unimpeded movement by the various life stages of Rio Grande silvery minnow appeared to exist. The recovery team recognizes that, if reestablishment in a selected reach were to occur, not all sections within the reach would be suitable macrohabitat for this taxon (i.e., dam outfalls and river-reservoir confluence). The extent and impact of these unfavorable macrohabitats on Rio Grande silvery minnow would probably vary annually and be dependent on antecedent and current hydrologic conditions. The extent of unfavorable habitats was deemed minimal compared with cumulative length of the potential suitable habitat within a reach.

Habitat within a particular reach is also an important factor in selecting reestablishment sites. The drifting early life history stages of Rio Grande silvery minnow are subject to downstream displacement and the extent of this movement is, in part, dictated by the stream habitats available in a particular reach. Areas where a river channel has been greatly reduced in width and where river meandering has been largely eliminated are generally typified by deeper and faster-velocity waters. There is also an associated reduction in the relative frequency of lower-velocity mesohabitats (i.e., pools and backwaters) that are favored by Rio Grande silvery minnow. The loss of lower-velocity habitats could result in increased downstream displacement of Rio Grande silvery minnow (especially drifting eggs and larvae). River reaches that were typified by these degraded habitats were not favored as highly by the recovery team as were reaches where the river channel was wider and allowed more freedom of movement.

Based upon the following reach-by-reach analysis and consideration of: 1) the understanding of reasons for the species' extirpation from the selected reach; 2) the presence of other members of the reproductive guild (pelagic spawner; non-adhesive, semibuoyant eggs); 3) habitat conditions (including susceptibility to river drying and presence of diversion structures); and 4) the presence of congeners (i.e., other species of *Hybognathus*), the following list of reaches or portions of reaches were selected to be most suitable for reestablishment and prioritized as follows:

1. Rio Grande, Presidio to Amistad Reservoir

2. Rio Grande, Amistad Reservoir to Falcon Reservoir
3. Pecos River, Sumner Dam to Brantley Reservoir
4. Pecos River, Red Bluff Reservoir to Amistad Reservoir
5. Rio Grande, Elephant Butte Reservoir to Presidio
6. Pecos River, Brantley Dam to Red Bluff Reservoir

Reach-by-Reach Descriptions

Rio Grande - Rio Grande Above Cochiti Lake

Hydrology: This reach has perennial flow. The hydrograph has a relatively natural shape with a spring peak that follows snowmelt runoff. On the Rio Chama below Abiquiu Dam, the summer and fall flows are higher than natural due to increased reservoir releases, including releases from the San Juan-Chama Project. This reach is likely not subject to a large increased diversion demand from future growth. There will be average increases in population growth and increased demand for use of groundwater. The Pueblos in this reach have aboriginal water rights which are vested, recognized, and protected under federal law, but which may not be currently in use. Exercising those rights does not require any transfer of existing rights as offsets. Any increase in non tribal water use, however, will require transfer of existing water rights as offsets.

The majority of this reach is canyon-bound with the remainder in open flood plain. From Otowi bridge upstream to the Velarde-Embudo reach it is non-canyon bound. Channel widths for 1935 averaged 300 ft. In 1972, the channel averaged only 155 ft, though it widened to an average of 190 ft by 1992. The canyon-bound reach has a high gradient, with a lower gradient in the open reaches. The substrate is dominated by gravel, cobble, and boulder, with little fine material. The overall amount of overbank flooding is not significant. There is low sinuosity and little segmentation, with the exception of several concrete instream diversion structures near Velarde.

Sections of the Rio Chama have levees and the Española valley has a history of channel maintenance activities. This area on the Rio Chama also contains instream diversions. In general, this reach appears stable in location and elevation with little aggradation or degradation. However, the planform is changing towards a meandering channel with sections of multiple channels or braids, causing the main channel to become less stable. Physically, the channel is widening and sediment is decreasing in grain size.

Water quality: This is a cold-water reach with low conductivity and turbidity. Some tributary streams that enter this section can introduce high sediment loads during storm events. There are point discharges from wastewater effluent from the communities upstream, but the water quality of the reach is most influenced by non-point sources. There are historic and current sources from mining and heavy metals in the Red River drainage that then enter the Rio Grande. The Rio Grande in this reach does not always fully support the designated fishery use due to turbidity, reduction of riparian vegetation, streambank destabilization, and metals.

Fish community: This reach is dominated by cool- and cold-water species, including longnose dace. There has been a replacement of most native species by introduced non-natives. Predation in this reach is from trout and northern pike. The Rio Grande silvery minnow was historically

present but has not been collected since 1949 in the Rio Chama and the 1970s in the Rio Grande. There is no niche competition from other fish in this reach.

Last collection of Rio Grande silvery minnow: 1962-1963

Further study: Contaminants from Red River and Los Alamos, additional fish studies.

Reestablishment potential: Low. Only 50-60 miles of marginal habitat available; flows are perennial.

Cause of extirpation: Loss of habitat, dam construction, cold water temperatures, loss of suitable substrate, change in hydrology, chronic/acute contaminants exposure, competition with introduced non-native fish species.

Rio Grande - Cochiti Reach

Hydrology: This reach has perennial flow. The hydrograph is modified to reduce the peak in some years, with extended release in years of high inflow. Under flood control operations, Cochiti Dam passes flows ranging from about 5,000 cubic feet per second (cfs) to 8,500 cfs, depending upon downstream channel conditions. There is a spring peak that coincides with snowmelt runoff. Storm runoff can enter from Galisteo and Tonque arroyos.

This reach has levees on the east side and is incised in the upper sections. The amount of sand-sized material from upstream sources has dropped to almost zero due to sediment capture by Cochiti Dam and a lack of upstream sources of sediment (Lagasse 1980). The substrate is armored cobble in the upper section. The arroyos introduce sediment to the lower sections of this reach and a higher percentage of finer sediments are found on the surface of the armored cobble, resulting in a bi-modal sediment distribution (Massong et al. 2002). This finer sediment moves downstream with higher flows. The streambed gradient is moderate and lower than the reach above Cochiti.

This reach has low sinuosity and routine channel maintenance activities are performed (mainly bank stabilization activities). The channel platform has changed from a mostly straight, low-flow braided morphology to a more sinuous meandering morphology (Massong et al. 2002b). The wetted width was less than 300 ft in 1998, indicating that the channel has continued its narrowing trend. The segmentation in this reach is limited to the Angostura Diversion Dam on the downstream end and Cochiti Dam on the upstream end. There is low habitat variability in this reach. Current estimates of overbank flooding are similar to levels found in the 1960s (10-15 percent of the wetted surface as overbank), while the amount was higher between the 1970s and 1990s (30-40 percent overbank surface area). Channel depth has increased from less than 3 ft to 4 ft, coinciding with the channel conversion to meandering. Significant aggradation has occurred just upstream and downstream of the Arroyo Tonque since 1992, possibly indicating an increased supply of sediment from this tributary.

Water quality: The water temperature is cold, due to release from Cochiti Reservoir. The water temperature warms during summer in the downstream reaches. This reach has low conductivity and turbidity except for when sediments are introduced during storm events. The water quality is

most influenced by non-point sources throughout the reach. This reach of the river does not always fully support its designated fishery uses, due to metals, reduction of riparian vegetation, and streambank destabilization.

Fish community: The fish community in this reach is almost exclusively non-native fish, dominated by white suckers and black bass and sunfish escapement from Cochiti Lake. There is no niche competition and this reach likely has the lowest density of Rio Grande silvery minnow of the areas currently containing populations of Rio Grande silvery minnow. The last known observations of silvery minnow in this reach were in 1995.

Further study: Habitat quality (temperature and substrate), return flows, flow management, institutional constraints (e.g., Cochiti re-regulation, Rio Grande Compact), channel management studies, monitoring fish populations.

Reasons for decline: Physical alterations in the channel (width/depth ratios, temperatures, substrate), fragmentation, flow regime changes, Cochiti Dam acting as a physical barrier with colder clean tailwater, loss of low water/high water refugia, channelization, contaminants (past acute exposures resulting from mine waste spills), colder temperatures and clearer water generated by establishment of a permanent recreation pool at Cochiti Lake, Galisteo sediment and flood control structure, non-native fish introductions.

Rio Grande – Angostura Reach

Hydrology: This reach has perennial flow. The hydrograph follows the seasonal peaks released from Cochiti Dam, reduced by the water diverted for irrigation at Angostura. Downstream demands for irrigation augment flows in this reach during the summer season. Flows in this reach are highly managed. There are significant storm events that add to the runoff in this reach. The channel now fully conveys the two-year event without using the floodplain.

This reach has a low gradient with a slightly meandering form in the upper section of the reach, and a much more highly braided channel in the lower section (Massong et al. 2002b). Vegetated islands have created multiple channels within this braided morphology. The river channel is leveed with jetty jacks at various locations. There is a high level of channel maintenance activity in the channel. A small amount of channel bed incision has generally occurred, with higher abandoned floodplain surfaces found near the New Mexico Highway 550 bridge. This reach has high habitat variability due to the channel braiding. Population growth remains high in the urban areas of this reach. The City of Albuquerque is developing a surface diversion to utilize its contracted water from the San Juan-Chama Project. This could result in partial habitat segmentation from the diversion structure within the reach. There are a number of return flows from riverside drains and inflows from the Jemez River.

Although the channel width has not changed much over time, the maximum channel depth has doubled, increasing from about three feet to over six feet during the 1990s. This change in channel bed depth is consistent with increased sediment size, bed incision, and reduced flooding, while changing from a shallow and consistently braided channel to a deeper, meandering channel.

Water quality: This is a warm-water reach. Conductivity is low and turbidity is low to moderate, except during storm runoff events. There are major urban point source inflows in this reach and non-point sources from both urban and agricultural areas.

This reach does not fully support the fishery, irrigation, and recreational designated uses, due to habitat alteration as well as metals, un-ionized ammonia, chlorine, and pathogens. During the past few years there have been several sewage spills and the reach is highly vulnerable to acute toxicity, due to treatment of these and other spill events.

Fish community: This reach is dominated by a warm-water fish community. There is a low predator population, mostly dominated by channel catfish. The Rio Grande silvery minnow is present. There is no niche competition in this reach for the Rio Grande silvery minnow.

Further study: Water quality impacts and sources, diversion structure modification, river and canal transmission losses, and conjunctive use of municipal supply.

Threats: Full use of all water in the system leading to dry reaches of river, contaminants (both acute and chronic).

Reasons for decline: Channel maintenance activities, Jemez flood and sediment control dam, contaminants (storm drains and municipal water treatment effluent discharge), dewatering.

Rio Grande – Isleta Reach

Hydrology: This reach is not perennial. The river has a spring peak that reflects the Cochiti releases and storm peaks. The flow in this reach is highly managed for human uses. There are several riverside drains that can maintain flows in some sections of the reach. These drains are near Bernardo and San Acacia. More urbanization is anticipated in this reach, but it may not result in a change in river flows.

The river is leveed on both banks, especially through Belen. There are channel maintenance activities and jetty jacks in the reach. This is a low-gradient reach dominated by sand substrate, with significant sediment inflows from Rio Puerco and Rio Salado. Since the 1960s, the main channel has widened to about 500 ft; it remained about this wide from 1972 to 1998 (Massong et al. 2002). The upstream channel has become shallower, decreasing from 3.5 ft to 2.5 ft, while the downstream channel depth has increased about 1 foot since 1962. The emergence of stable vegetating islands has coincided with a decrease in the amount of overbank flooding, from an estimated 60 percent of wetted surface area down to 1 percent in 1998. The river bed within the lower reach aggrades due to sediment load, principally due to discharge from the Rio Puerco and Rio Salado. There is increased channel mobility downstream of the Rio Puerco. Habitat variability is high within the reach. There are no constructed barriers within the reach but it becomes fragmented due to ephemeral flows. Although the channel width appears stable in this reach, the channel will continue to incise with coarsening sediment, and will possibly become meandering.

Water quality: Water temperature, conductivity, and turbidity are higher than in the upstream reach. Water quality is dominated by non-point source discharges. Portions of this reach do not fully support the fishery designated use, due to metals and habitat alteration.

Fish community: This reach is predominantly a warm-water native fish community. There may be predation by channel catfish. The Rio Grande silvery minnow is present in the reach with no niche competition.

Further study: Water quality and sediment quality impacts from the Rio Puerco, Rio Salado and return flows, channel loss studies, phreatophyte evapotranspiration water use budgets, channel conveyance efficiencies, efficient application of irrigation water, and conjunctive use of municipal supply.

Threats: Full use of all water in the system leading to dry reaches of river; contaminants.

Reasons for decline: Dewatering and water quality.

Rio Grande - San Acacia Reach

Hydrology: This reach is not perennial, although the spring runoff peaks and summer storm peaks often maintain surface flow. There is a high degree of flow manipulation outside of storm events. There is a stable human population base and the demand should be relatively stable.

The river is leveed on the west bank and open on the east. The Low Flow Conveyance Channel begins at San Acacia Diversion Dam. The first 21 miles of the Socorro Reach is a straight and incised river with extensive channel sections exhibiting a bi-modal bed composition with distinct layers of sand and gravel (Massong et al. 2002a, b). Gravel-sized sediment has become abundant since the late 1990s. This section of channel is changing towards a single-threaded channel with a slightly meandering thalweg, which is the deepest part of the channel. However, sections are still wide and sandy, with a braided morphology. Sediment transport and stable slope calculations indicate that the current channel is relatively stable for the gravel sizes present, rather than the historic sand substrate.

In the middle section of the reach, the channel has a sand-silt substrate, is aggrading, and typically has a braided morphology (Massong et al. 2002). The lack of flooding in 1992 may be a direct result of the larger flows in the 1980s, increasing channel width to 525 ft. The channel width decreased in the 1990s with the relatively smaller peak flows. Terraces mapped in 2000 (Makar and Klawon 2000), indicate that just downstream of the N.M. Hwy. 380 bridge, only low terraces exist (~3 ft), and they do not confine the channel. Habitat variability is moderate, due to channelization.

The last 30 miles of this reach is mostly a single-threaded channel, due to past channelization activities (Massong et al. 2002). Below San Marcial, in the 1990s overbank flooding increased up to 70-80 percent of the wetted surface area. The lower reach begins flooding when discharges reach 2,000 to 3,000 cfs. The river channel in the section near San Marcial has been reconstructed, following inundation from the previous times when Elephant Butte Reservoir was full. Excavation within maximum reservoir pool is used to open pilot channels to maintain flows

into the lake. Increases in the level of channel flooding with a lower discharge are consistent with an aggrading system. Two features that do not meet the classic features of the aggrading system are the channel width and depth. Ideally, the width would increase and the depth would decrease; however, with a dense riparian zone and clay banks creating stable channel boundaries, the channel will probably maintain constant width and depth.

Water quality: This is a warm-water reach with higher levels of conductivity and turbidity than upstream. The water quality is dominated by non-point source discharges.

Portions of this reach do not fully support its fishery designated use, due to pesticides, reduction of riparian vegetation, and streambank destabilization.

Fish community: The fish community is dominated by warm-water native species. There is a predatory channel catfish population. There is no niche competition. When Elephant Butte Reservoir is low, there is increased riverine habitat in the lower sections of the reach.

Further study: Water quality and sediment quality impacts, channel loss studies, phreatophyte evapotranspiration water use budgets (i.e., the loss of water through evaporation from the leaves of a deep-rooted plant that obtains its water from the water table or the layer of soil just above it), channel conveyance efficiencies, efficient application of irrigation water, and conjunctive use.

Threats: Full use of all water in the system, leading to dry reaches of river; contaminants.

Reasons for decline: Dewatering and water quality.

Rio Grande - Elephant Butte Reservoir to Presidio

Hydrology: The river is not perennial in this reach. There is a highly regulated flow regime and no spring runoff peak. There is an anticipated above-average change in demand with an increased possibility for perennial flow in this reach, due to change in water use from agricultural to urban uses. Releases in this reach are constrained by the Rio Grande Compact and downstream water demands.

There are many barriers in this reach, with the major structure being Caballo Dam. Portions of the river are completely channelized with sand substrate, straight channel, high channel-maintenance activity, and levees in most areas. Water flows in the stretch below El Paso to near Presidio, Texas, come primarily from irrigation return flows and wastewater returns.

Water quality: This is a warm-water reach with higher levels of conductivity than in upstream areas. The water quality is dominated by significant point and non-point source discharges. Within the reach, the El Paso area is heavily industrialized compared to upstream reaches. The reach also receives both point and non-point source discharges from the Mexican side of the river, which is subject to different water quality regulations than are discharges in the United States.

Portions of this reach do not fully support its fishery and irrigation designated uses, due to metals, siltation, un-ionized ammonia, chlorine, pH, reduction of riparian vegetation, and streambank destabilization.

Fish community: This reach has a mixed cold- and warm-water fishery between the Elephant Butte release and Caballo Reservoir. The river from Caballo Dam to Fort Quitman has many elements of a warm-water, non-native fish community. The Rio Grande silvery minnow was historically present, but no longer is found in the reach. There are predators present, such as black bass and catfish, but no niche competitors.

Last collection of Rio Grande silvery minnow: 1944; Caballo Reservoir to the Texas-New Mexico state boundary.

Further study: None at this time.

Reestablishment potential: Low; a short distance from Elephant Butte Dam to Caballo Reservoir, low temperatures downstream of dams, and low dissolved oxygen levels are all problems. The reach below Caballo Dam is channelized, and the section from below El Paso to Presidio, Texas, is heavily overgrown with salt cedar (*Tamarix*).

Cause of extirpation: Water quality degradation, channelization, change in hydrology, diversion (physical barriers and de-watering).

Rio Grande - Presidio to Amistad Reservoir

Hydrology: The river in this reach is perennial, and is dominated by the Rio Conchos entering from the Mexican side of the river. Flow reductions only occurred during the severest droughts of the 1950s, until 2003, when portions of this reach again ceased to flow. There is a seasonal peak modified by upstream dams on the Rio Conchos. The peak is short due to water diversions and upstream dams in the Rio Conchos. There are large storm event peaks in October and November. There are increases in depletion anticipated, due to increased irrigation on the Mexican side of the river. The Treaty of 1944 sets the upper limit for the amount of diversion, but this may not be enforced.

This reach is not leveed and has small rock dam weirs. The substrate ranges from silt to cobble and boulder, depending on local conditions. There are no channel maintenance activities in this reach. Almost half of this reach is in canyons, including Big Bend National Park. The lower canyon reach is outside the park, but land use is managed by the National Park Service as a part of the Rio Grande's Wild and Scenic River designation in this stretch.

The channel is not mobile in the canyon sections. Outside the canyon reaches, the river is braided in some sections with a moderate gradient on average but higher gradient relative to the immediate upstream reach. Base flow in this reach is approximately 400 cfs.

Water quality: The river in this reach has high salinity and turbidity. This reach has both point and non-point source discharges, with the water quality dominated by contributions from the Rio Conchos.

Fish community: This reach has a warm-water native fish community with some non-natives. The reach has a high number of large river species, such as smallmouth buffalo. The main predator is blue catfish. The Rio Grande silvery minnow was historically present in this reach, but is no longer present. There is no niche competition.

Last collection of Rio Grande silvery minnow: 1960.

Further study: Existing fish community, water quality data from Rio Conchos gage.

Reestablishment potential: Good.

Cause of extirpation: Poor water quality (Rio Conchos), loss of natural hydrograph, diversion (de-watering).

Rio Grande - Amistad Reservoir to Falcon Reservoir

Hydrology: This reach is perennial with a small seasonal peak due to delivery schedules. Flow in this reach is highly regulated, due to water releases to satisfy demands for irrigation in both Texas and Mexico. This reach is administered by a water master. The base flow is approximately 1,000-3,000 cfs. The demand in this reach is relatively stable but there is a conversion from agricultural to municipal uses. This reach is also subject to daily fluctuations to meet the downstream demands and for hydroelectric generation.

This section of the river is not leveed and there is no channel maintenance. The river is nearly straight with no braiding. The channel's gradient is lower than that of the immediate upstream reach and its substrate is variable, ranging from coarse material downstream of Amistad to a predominately sand substrate in the lower section of the reach. There are several barriers in this reach.

Water quality: This section of the river has warm water with relatively high salinity and low turbidity. There are both point and non-point source discharges.

Fish community: The fish in the reach are dominated by species with relatively high predator populations, including centrarchids and striped bass. There are several native minnow species, but Rio Grande silvery minnow is absent.

Last collection of Rio Grande silvery minnow: Inferred, prior to 1960.

Further study: Water quality, fish collection data, reestablishment potential.

Reestablishment potential: Moderate; significant flows are removed for irrigation near Quemado and non-native riparian vegetation (especially giant reed) is problematic.

Cause of extirpation: Poor water quality (agriculture discharge, saline intrusion), change in hydrology (regulated flows).

Rio Grande - Falcon Dam to Gulf of Mexico
Hydrology: This reach is perennial and is highly regulated by releases from Falcon Dam. Base flow is approximately 500 to 1,000 cfs. There is a high level of urbanization. The peak flows are caused by spills from the reservoir, due to storm peaks or reservoir releases for irrigation. The river channel is stable with a low gradient and levees along some sections. There are barriers in the form of flood control structures. The substrate is dominated by sand with other particle size-classes present.

Water quality: Water quality in this reach is brackish, due to influences from the Gulf of Mexico. Turbidity is low near Falcon Dam and increases in the downstream direction. There are both point and non-point source discharges from the increased urbanization and agriculture.

Fish community: A significant component of the fish community is warm-water non-natives, including estuarine species in the lower river near Brownsville. There is a high predator population and no niche competitors.

Last collection of Rio Grande silvery minnow: 1961.

Further study: Evaluate reestablishment potential.

Reestablishment potential: Low.

Cause of extirpation: Estuarine conditions, predation, water quality, change in hydrology, diversion (physical barriers).

Pecos River - Santa Rosa to Carlsbad
Hydrology: This reach is not perennial. The flows are regulated by dams near Santa Rosa and Fort Sumner. The reach from Santa Rosa Dam to Sumner Dam is short relative to the length needed by the Rio Grande silvery minnow.

There are storm peaks during rain events, but significant spring peaks do not occur every year. There is no change in demand anticipated. The reach of river from Santa Rosa to Roswell loses flow, but that from Roswell downstream to Carlsbad gains flow. The channel from Sumner Dam to Roswell has a moderate gradient with braiding within the stream margins, as well as small sections of multiple channels. Substrate in this reach is variable, with gradations from small to large substrate sizes. The upper section of this reach is similar in characteristics to the upper Rio Grande near Velarde.

The section from Roswell to Carlsbad is perennial. The gradient is moderate to low from Roswell to Carlsbad. The channel from Santa Rosa Dam to Sumner Dam is single with in-channel braiding. There is a single channel with channel braiding from Sumner Dam to Roswell. The lowest section of the reach has no braiding. Substrate in the river is cobble from Santa Rosa Dam to Sumner Dam, sand from Sumner Dam to Roswell, and sand/silt from Roswell to Brantley Reservoir. There is low channel mobility in the entire reach.

Water quality: The upper portion of this reach has cool water downstream of Santa Rosa Dam and warm water downstream of Sumner Dam. The conductivity and turbidity are low in the upper sections. The reach from Sumner Dam to Roswell has high turbidity and is highly variable in the downstream section. Salinity is high in the lower section of the reach.

Portions of this reach do not fully support the fishery designated uses, due to metals, pathogens, reduction of riparian vegetation, streambank destabilization, dissolved oxygen, un-ionized ammonia, and total dissolved solids.

Fish community: The fish community is dominated by warm-water native species. The Rio Grande silvery minnow was historically present, but is not currently found here. There is a low predator population in the upper sections and a low-to-moderate predator population in the section from Roswell to Brantley Reservoir. There are no niche competitors from Santa Rosa Dam to Sumner Dam, but there is potential niche competition by non-native plains minnow from Sumner Dam downstream.

Last collection of Rio Grande silvery minnow: 1968 (Roswell).

Further study: Pecos hydrology (Sumner Dam to Acme), additional fish recovery areas.

Reestablishment potential: Low above Sumner Dam (short reach); moderate below Sumner Dam. Prior to any attempt to reestablish Rio Grande silvery minnow in the Pecos River, the plains minnow must be extirpated.

Cause of extirpation: Santa Rosa Dam to Sumner Dam: short reach (reproductive strategy requires more river channel). Below Sumner Dam: salinity, plains minnow, dams, loss of suitable substrate, intermittent flow in river channel, change in flow regime, loss of spring peak flows, diversion (de-watering).

Pecos River - Red Bluff Reservoir to Amistad Reservoir

Hydrology: This reach is perennial. It does have storm events evident in the hydrograph in the lower sections of the river. Flows in the upper portion are dominated by releases from Red Bluff Dam. The lower section has significant spring sources and groundwater inflows that contribute to the discharge. There are no anticipated changes to flow regimes from increased demands for human uses.

This reach is a single channel, braided within the channel margins but without levees. The river gradient is high in the lower half of the reach with variable substrate types. There are some barriers in the upper section.

Water quality: This reach is typified by warm water with high conductivity and low turbidity, and is dominated by non-point source contaminants. It is subject to algal blooms from unknown causes, which have caused massive fish die-offs. Portions of this reach do not fully support the fishery, irrigation, and livestock and wildlife watering designated uses, due to metals, un-ionized ammonia, siltation, salinity, reduction of riparian vegetation, and streambank destabilization.

Fish community: The fish community is composed of warm-water native and non-natives species, with moderate predation from catfish and black bass. The Rio Grande silvery minnow was historically present but no longer inhabits the reach. There are no niche competitors present in this reach.

Last collection of Rio Grande silvery minnow: 1954 (low numbers in collection).

Further study: Study hydrology below Fort Stockton, evaluate reestablishment potential.

Reestablishment potential: Unknown.

Cause of extirpation: Salinity, limited habitat, change in hydrology due to wells, diversions (physical obstructions & dewatering).

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APPENDIX G
GLOSSARY

Back water – a body of water, connected to the main channel, with no appreciable flow; often created by a drop in flow that partially isolates a former channel.

Congener – an organism that belongs to the same taxonomic group as another organism.

Cyprinid – a member of the family Cyprinidae, which includes minnows, carps, and shiners.

Eddy – a pool with current moving opposite to that in the channel.

Flat – a region of uniform shallow depth, moderate velocity, and sand substrate.

Isolated pool – a pool that is not connected to the main or secondary channel; frequently a former backwater that is no longer connected to the main or secondary channel.

Main channel – the section of the river that carries the majority of the flow; there can be only one main channel.

Pool – the portion of the river that is deep and has relatively little velocity compared to the rest of the channel.

Riffle – a shallow and high-velocity habitat where the water surface is irregular and broken by waves; generally indicates gravel-cobble substrate.

Run – a reach of relatively high-velocity water with laminar flow and a non-turbulent surface.

Secondary channel – all channels not designated as the main channel; there may be zero or several secondary channels at a site.

Standard length – the distance between the tip of the snout and the base of the tail (versus the end of the tail).

Substrate – substrates are defined in part by their particle size (diameter).

- Boulder: > 256 mm
- Cobble: 64-256 mm
- Gravel: 2-64 mm
- Sand: 0.0625-2 mm
- Silt: < 0.0625 mm

APPENDIX H
ACRONYMS

afy – acre-feet per year
BBNP – Big Bend National Park
BOR – U.S. Bureau of Reclamation
cfs – cubic feet per second
COE – U.S. Army Corps of Engineers
CPUE – catch per unit effort
EPA – Environmental Protection Agency
ESA – Endangered Species Act
FWS – U.S. Fish and Wildlife Service (Service)
IBWC – International Boundary and Water Commission
ISC – Interstate Stream Commission
LFCC – Low Flow Conveyance Channel
MRGCD – Middle Rio Grande Conservancy District
MRGESCP – Middle Rio Grande Endangered Species Collaborative Program
N_e – effective population size
NMDGF – New Mexico Department of Game and Fish
OSE – Office of the State Engineer, New Mexico
PVA – population viability analysis
Service – U.S. Fish and Wildlife Service (FWS)
SL – standard length
SOR – Statement of Relationship
TCEQ – Texas Commission on Environmental Quality
TPWD - Texas Parks and Wildlife Department
TL – total length
USGS – U.S. Geological Survey
WWTP – waste water treatment plants

Appendix I

Rio Grande Silvery Minnow Population Viability Analysis: a Tool to Evaluate Progress Toward Recovery

The following document presents a Population Viability Analysis (PVA) developed for the Rio Grande silvery minnow. A PVA is a model designed to evaluate the relative effects of demographic stochasticity, environmental variation, and certain management activities on a population's long-term extinction risk. A PVA for the Rio Grande silvery minnow was developed through a series of workshops and technical meetings held from September 2007 through August 2008. The model described below is designed to represent and evaluate the Big Bend population only. This PVA assessment will be useful to both determine stocking rates, and over the longer term, as information about the reintroduced population becomes available evaluate its extinction risk (and associated progress toward recovery). Model development and refinement is ongoing, but initial results provide important insight into pressing research needs and priorities for recovery action. As this model is further refined, it expected to serve as a useful tool for evaluating progress toward meeting the recovery criteria presented in Section 3.0.

Introduction

The Rio Grande silvery minnow (*Hybognathus amarus*) historically occupied approximately 3,862 river km (2,400 mi) in New Mexico and Texas. It was found in the Rio Grande from Española, New Mexico, down through Texas to the Gulf of Mexico (Bestgen and Platania 1991). It was also found in the Pecos River, a major tributary of the Rio Grande, from Santa Rosa, New Mexico, downstream to its confluence with the Rio Grande River in Texas. Currently, the Rio Grande silvery minnow is believed to occur in only one reach of the Rio Grande in New Mexico, a 280 km (174 mi) stretch of river that runs from Cochiti Dam to the headwaters of Elephant Butte Reservoir. This includes a small portion of the lower Jemez River, a tributary to the Rio Grande north of Albuquerque. In December 2008, silvery minnows were introduced into the Rio Grande near Big Bend, Texas as a nonessential, experimental population under section 10(j) of the ESA (73 FR 74357). Preliminary monitoring is being conducted to determine whether or not that reintroduction has been successful. Its current habitat is limited to about seven percent of its former range. The species was listed as federally endangered in 1994 (59 FR 36988).

Increasing demands for available water in this area, particularly in and around Albuquerque, New Mexico, have altered the normal hydrologic and ecological processes in the Rio Grande. Ongoing drought in this area of the United States has exacerbated these problems still further. As a result, the long-term persistence of endangered species such as the Rio Grande silvery minnow will likely be compromised to a greater degree. To facilitate long-term recovery of this species, the U.S. Fish and Wildlife Service seeks to reintroduce the species into three locations within its historic range. The first of these reintroductions is targeted for the stretch of the Rio Grande within the confines of Big Bend National Park (BBNP) along the border between the United States and Mexico.

Population viability analysis can be an extremely useful tool for designing optimal reintroduction strategies within the area of interest. *RAMAS METAPOP*, a simulation software package written

for PVA, was used here as a vehicle to study the interaction of a number of silvery minnow life history and population parameters, and to begin testing the relative efficacy of alternative reintroduction strategies.

The *RAMAS* package is a simulation of the effects of a number of different natural and human-mediated forces – some, by definition, acting unpredictably from year to year – on the health and integrity of wildlife populations. *RAMAS* models population dynamics as discrete sequential events (e.g., births, deaths, sex ratios among offspring, catastrophes, etc.) that occur according to defined probabilities. The probabilities of events are modeled as constants or random variables that follow specified distributions. The package simulates a population by recreating the essential series of events that describe the typical life cycles of sexually reproducing organisms.

Population viability analysis methodologies are not intended to give absolute and accurate "answers" for what the future will bring for a given wildlife species or population. This limitation arises simply from two fundamental facts about the natural world: it is inherently unpredictable in its detailed behavior; and we will never fully understand its precise mechanics. Consequently, many researchers have cautioned against the exclusive use of absolute results from a PVA in order to promote specific management actions for threatened populations (Ludwig 1999; Beissinger and McCullough 2002; Reed et al. 2002; Ellner et al. 2002; Lotts et al. 2004). Instead, the true value of an analysis of this type lies in the assembly and critical analysis of the available information on the species and its ecology, and in the ability to compare the quantitative metrics of population performance that emerge from a suite of simulations, with each simulation representing a specific scenario and its inherent assumptions about the available data and a proposed method of population and/or landscape management. Interpretation of this type of output depends strongly upon our knowledge of Rio Grande silvery minnow in its habitat, the environmental conditions affecting the species, and possible future changes in these conditions.

The *RAMAS* system for conducting population viability analysis is a flexible and accessible tool that can be adapted to a wide variety of species types and life histories as the situation warrants. This makes it a trusted method for assisting in the definition of practical wildlife management methodologies. For a more detailed explanation of the program and its use in population viability analysis, refer to Akçakaya (2005).

Specifically, we were interested in using this analysis to address the following questions:
What management actions help prevent extinction in the Middle Rio Grande in the short term.

- What would be the minimum number of silvery minnow required for successful stocking at the outset of a reintroduction program?
- Is augmentation of this initial stocked population necessary to achieve a successful reintroduction effort? If so, how many fish are needed each year, assuming a given duration of the augmentation effort?
- What is the expected underlying minnow population growth rate that would be required to provide a high probability of a successful reintroduction effort?
- Does invasion of the BBNP reintroduction site by giant river cane (*Arundinaria gigantea*) pose a significant threat to establishment of a viable population of silvery minnow in the lower Rio Grande?

Baseline Input Parameters for Stochastic Population Viability Simulations

The biological information used to develop demographic input for these PVA models comes from a variety of published and unpublished sources. Of greatest relevance to this process is the series of meetings involving members of the Rio Grande Silvery Minnow Biology Working Group and associated invited guests. This group was composed of representatives from a number of diverse agencies and other interested parties, including:

- U.S. Fish and Wildlife Service
- U.S. Army Corps of Engineers
- Interstate Stream Commission
- New Mexico Department of Game & Fish
- The Offices of Senators Bingaman and Domenici
- City of Albuquerque
- Bureau of Reclamation
- American Southwest Ichthyological Research Foundation
- Bureau of Indian Affairs
- Santa Ana Pueblo
- SWCA Environmental Consultants
- University of New Mexico
- Texas Parks and Wildlife Department
- National Park Service
- Utah State University
- University of Texas – Pan American
- U.S. Geological Survey
- Texas Water Development Board

Through many days of meetings and discussions, this group provided and evaluated data and information in an open and productive process. As a result, while some differences of opinion remain concerning the interpretation of selected elements of the data, and while significant gaps in our definitive knowledge of the species' biology remain, the information discussed below represents our collective understanding to date of Rio Grande silvery minnow demography and population ecology.

Structure of Demographic Information Used in PVA

The analysis discussed here employs an age-structured matrix model of silvery minnow demography, with input data on age-specific fecundity and survival rates based on an assumed pre-breeding census methodology. The matrix that describes these demographic rates, known as a Leslie Matrix, is algebraically combined with a description of this year's population to project the size of that population in the next year. Specifically, if we assume that a species lives until

just beyond two years of age, we can describe one year's change in population size algebraically by:

$$\begin{bmatrix} N_0(t+1) \\ N_1(t+1) \end{bmatrix} = \begin{bmatrix} F_0 & F_1 \\ S_1 & 0 \end{bmatrix} \begin{bmatrix} N_0(t) \\ N_1(t) \end{bmatrix}$$

where $N_0(t+1)$ and $N_0(t)$ are the numbers of individuals in age class 0 (here, 0 – 12 months) at time (t+1) and (t), respectively; F_0 is the fecundity of age 0 individuals (defined here as the average number of offspring that are produced by individuals in age class 0 and are censused at the next time step); and S_1 is the survival rate of individuals in age class 1 (i.e., the proportion of individuals that survive from 12 months to 24 months of age). Note that the Leslie matrix value in the lower-right corner is automatically set to 0 because, in this case, we assume that individuals do not live to see their third birthday. Therefore, survival rates beyond 24 months of age are 0.0.

The process of developing input data for the PVA revolves largely around the estimation of the fecundity and survival rates that define the Leslie matrix. Moreover, it is important to remember that we assume that these age-specific demographic rates are not static in time, but instead fluctuate randomly from one year to the next in response to changes in the external environment within which the minnow lives. Consequently, in addition to estimating mean rates of birth and survival we must also try to assess the degree to which these rates fluctuate through time.

We decided to construct a matrix model for the Rio Grande silvery minnow that includes only females. This is a rather common approach in the matrix-based analysis of wildlife populations in which there are few if any measurable differences in demographic behavior between males and females. With this formulation, we were interested only in the number of female offspring produced by a given adult female, and only in the survival rates of female fish in each age class. This approach simplifies the overall computational structure and also reduces the number of required variables and, more importantly, their measurement uncertainty.

Finally, we assumed that only two age classes are required to adequately describe the demographics of the Rio Grande silvery minnow. Specifically, we defined Age 0 fish as those that are produced immediately after the preceding census and live to the next census when they are counted as 12 months old. Additionally, we defined Age 1 fish as those that are 12 months old in the current census and survive to be counted again in the next census as 24 months old. We further assumed that both Age 0 and Age 1 fish produce offspring, with the Age 1 fish dying soon after their second annual spawn and, therefore, failing to reach the next census as 36 months old. With this simplification, we acknowledged the potential for some silvery minnows to live beyond 36 months of age. However, given our survival estimates for younger fish (see below) we concluded that the total number who would reach this age are so few in number as to be of little to no demographic value. Early matrix analyses (which are not presented here but can be obtained from the lead author of this report) confirmed this expectation.

Age-specific demographic rates

Because silvery minnow are only known from the Middle Rio Grande, site-specific information for minnow demographic rates such as survival and/or fecundity, or the long-term rate of

population growth in reintroduction areas, are not available. Consequently, average rates of fecundity and survival were derived that would be expected to correspond to different identified rates of population growth that could occur following the early phases of population establishment. In other words, we assumed a given growth rate and then back-calculated the average rates of birth and death that would interact to produce the desired rate of growth. In this document, we express population growth by using the variable λ, where $\lambda > 1.0$ indicates population growth and $\lambda < 1.0$ indicates population decline.

Of course, a population with a long-term growth rate of $\lambda < 1.0$ would not be desirable in any kind of endangered species reintroduction effort. We therefore set our minimum acceptable long-term stochastic growth rate at $\lambda = 1.0$ (or very slightly higher). In addition to this minimum-condition alternative, we derived demographic rates that would produce long-term stochastic growth rates approximately equal to $\lambda = 1.025$ and $\lambda = 1.050$. These rates are to be observed in the absence of such limiting processes as density dependence in reproductive rates or the imposition of a habitat carrying capacity.

The three Leslie matrices corresponding to these underlying growth rates are shown below. It is important to remember that these are the desired *stochastic* growth rates. If conditions in some models change from the baseline conditions, actual growth rates obtained from simulation may be different from expectation.

$\lambda = 1.0$

$$\begin{bmatrix} 0.920 & 1.270 \\ 0.0796 & 0.000 \end{bmatrix}$$

$\lambda = 1.025$

$$\begin{bmatrix} 0.938 & 1.440 \\ 0.0796 & 0.000 \end{bmatrix}$$

$\lambda = 1.050$

$$\begin{bmatrix} 0.985 & 1.550 \\ 0.0796 & 0.000 \end{bmatrix}$$

F_0 is the fecundity of age 0 females (defined here as the average number of offspring that are produced by individuals in age class 0 and are censused at the next time step); and S_1 is the survival rate of females in age class 1 (i.e., the proportion of female individuals that survive from 12 months to 24 months of age). The rates specified in these matrices are similar in magnitude to those derived from actual field studies of silvery minnow population biology in the Middle Rio Grande.

Sources of variability in demographic rates

Annual environmental variation in demographic rates is modeled in *RAMAS* by specifying a standard deviation that is applied each year to the base rates in order to simulate fluctuations due to extrinsic factors (both natural and anthropogenic) in the environment within and near the middle Rio Grande. Specifically, we used a lognormal distribution of demographic rates over the period of the simulation, using the specific extent of environmental variation as the standard deviation of the distribution. The lognormal distribution is often a more accurate reflection of random variability in demographic rates, and often reduces truncation bias when describing rates bounded by 0 and 1.0.

Unfortunately, the methods to arrive at mean estimates of Rio Grande silvery minnow fecundity and survival described in the preceding section are effectively only "snapshots" of data within a short time period, often over a single year (spawning season). While there may be abundant data

on, for example, the *spatial* nature of variance in demographic rates, there is no way to estimate the *temporal* variation in these same rates from just one year of data. Instead of trying to accurately assign a particular level of environmental variability to fecundity and survival rates in the absence of appropriate data, we took a more exploratory approach to this facet of silvery minnow population biology. Specifically, we assumed in all models that the extent of environmental variability for each matrix element would be approximately equal to 25% of the mean demographic value (i.e., we assumed a coefficient of variation, CV, of 0.25). Therefore, if we assume the fecundity of Age 0 fish is 0.920 females produced per Age 0 female, our estimate of environmental stochasticity for this parameter would be 0.230.

In addition to environmental variability, our simulations include demographic stochasticity. This factor describes the uncertainty within a given year that arises when applying birth and death rates to a population that must be described in whole numbers (e.g., you cannot have 1.2 offspring per female, but only one or two offspring). This source of uncertainty is most important when populations become quite small, when such uncertainty can have major impacts on rates of fecundity or survival. To simulate demographic stochasticity in *RAMAS*, the number of survivors for the *i*th age class is drawn from a binomial distribution with parameters S_i (survival rate) and $N_i(t)$ (as sample size). The number of young produced by the *i*th age class is then drawn from a Poisson distribution with mean $F_i(t)N_i(t)$.

Initial population size and subsequent population augmentation

All models described here are assumed to be initiated immediately after a beginning introduction of individuals (specifically, females in our models) to the river. The number of fish added to the river at the beginning of the simulation was 50,000 or 100,000 or 150,000 females. We assumed that an equal number of males are added to the river as well, but are not explicitly considered in these models.

Following the initial group of fish added to the river, we considered the impact of differential levels of augmentation in subsequent years. Specifically, 50,000 or 100,000 or 150,000 females were added each year for a period of 5 years, beginning at year one and ending at year five. Under these conditions, the original fish which constitute the introduction were assumed to be effectively added just before the onset of the simulation, with the first augmentation event occurring near the end of the first year (e.g., autumn).

As the models are structured, we assumed no mortality between the time of the augmentation event and the following reproductive event occurring the next spring. Therefore, 100% of the fish added to the river in year *x* will be available to reproduce in year *x*+1. In reality, there would undoubtedly be some level of mortality of these fish during the intervening time period of interest; consequently, we could consider this augmentation to be an "effective augmentation" with the true augmentation equal to some larger number of individuals.

Density dependence and habitat carrying capacity

The regulation of one or more demographic rates by density is a nearly universal phenomenon among wildlife populations. Birth and/or survival rates can be reduced when density increases to

a point where competition for space or resources becomes critical; at the other extreme, very low population densities can lead to a reduction in breeding rates simply because individuals of the opposite sex have difficulties in finding each other to mate (known as the Allee effect). Therefore, a proper PVA must include at least some form of density-dependent regulation of vital rates.

At the present time, no studies exist that explicitly investigate density dependence in vital rates. We therefore relied on information from other species and expert opinion to derive some form of relationship. We assumed that Allee effects are not present, and that processes operating at high densities are most easily explained by a simpler ceiling model of density dependence. Under the ceiling type of density dependence, the population grows exponentially until it reaches the ceiling, also known as the carrying capacity K (e.g., until all available habitat is occupied), and then remains at that level. For large population sizes, the population size at t+1 is a constant function of the population size at t. A population that reaches the ceiling remains at that level until a population decline (e.g., a random fluctuation or an emigration) takes it below the ceiling.

Geomorphological and ecological analysis of the Rio Grande in and near Big Bend National Park suggests that about 60% of the river is composed of "alluvial reaches:" stretches of river with shallow-cut banks and ample low velocity areas that would provide good habitat for silvery minnow. The remaining 40% of the river is composed "canyon reaches," with steep, rocky banks and largely high-velocity areas that provide only small amounts of suitable silvery minnow breeding and feeding habitat. Therefore, for the purposes of calculating the total habitat availability we assumed alluvial reaches to occupy (0.6)(270 miles) = 162 miles = 260,700 m, while (0.4)(270 miles) = 108 miles = 173,800 m is in canyon reaches.

In order to calculate the average width of the river in alluvial reaches, we used baseflow channel width measurements observed by researchers from Utah State University at two reaches: Hot Springs Canyon to Boquillas Canyon, and Terlingua Creek to the Santa Elena crossing. The average baseflow width across these two reaches was 32m. This value was seen as representative of other reaches under baseflow conditions, so we adopted this width across all alluvial reaches.

In the absence of specific data we estimated that the full 162 miles of habitat in the alluvial reaches is available (wet) to the minnow on an annual basis.

After numerous discussions among working group members on this issue, spanning multiple meetings, a consensus was reached on a process for simulating carrying capacity throughout the middle Rio Grande with an acceptable degree of accuracy. Over the past 15 years of observation, the maximum density calculated from CPUE data is approximately 40 fish/100m^2. It is possible that this density may be even higher in a single year, although the likelihood of achieving such high densities is relatively small. More reasonably, we might expect the long-term maximum to be on the order to 30 fish/100 m^2, with some degree of variability around this value to simulate changes in local environmental conditions such as water availability, predator or competitor densities, etc. Using this logic, we set the average maximum density at 30 fish/100 m^2 with annual variability expressed in terms of a standard deviation in this density equal to approximately 6 fish/100 m^2. Additionally, we assumed that the sustainable density of silvery minnow in canyon reaches was just 3 fish/100 m^2. Using this range of densities, and applying

them to the reach-specific morphology data given above, we arrive at the following estimate for carrying capacity across alluvial reaches in the BBNP stretch of the Rio Grande River:

$K_{♀} = [(260{,}700m)(32m)(30fish/100m^2) + (173{,}800m)(32m)(3fish/100m^2)] / 2 \approx 1{,}300{,}000 \pm 250{,}000$

The variability around reach-specific carrying capacity is described by a normal distribution with mean *K* and the standard deviation specified above.

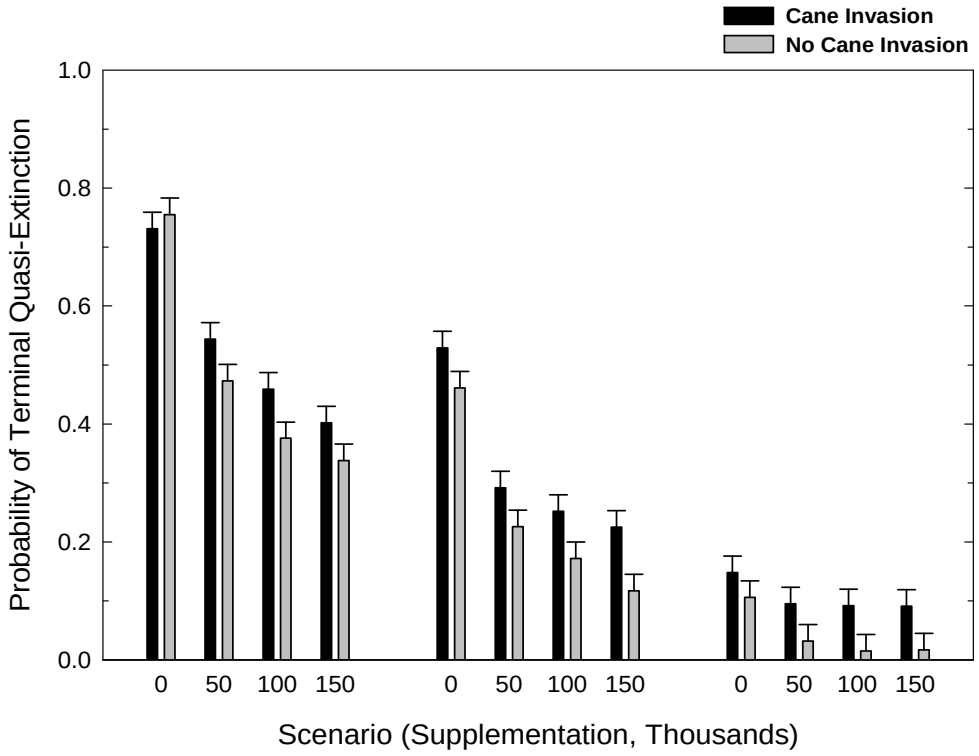
Simulating reduction in habitat availability through giant cane invasion

Currently, giant river cane (*Arundinaria gigantea*) is established in the Rio Grande River in and around Big Bend National Park. As the invasive plant expands its distribution, the amount of suitable habitat available to the silvery minnow declines. Declines in bankfull channel width (assumed to be attributable to declined hydrology, sediment surplus, vegetation induced sedimentation and stabilization of geomorphic surfaces) has been 1.2% per year between 1996 and 2004 (David Dean, Utah State University, pers. comm.). The channel has continued to contract since 2004; however, the declines in channel width are now probably less than 1.2%. Without active vegetation management, and assuming a big channel resetting monsoon does not occur in the near future, we anticipate declines in bankfull channel width to continue at a rate between 0.5% and 1% per year. To estimate the impact of this decline in channel width, we assumed that a 1% decline in baseflow channel width results in a 1% decline in available habitat, i.e., a 1% decline in K. Therefore, we constructed a set of models where K declined linearly by 1% per year for the duration of the simulation. In these models, the total carrying capacity was reduced by 50% by the end of the simulation.

Iterations and years of projection

Population trajectories for all combinations of initial population size and subsequent augmentation under lambda values of 1.00, 1.025, and 1.05 both with and without management of giant cane were simulated using the PVA model. All stochastic population projections (scenarios) were simulated 1000 times. Each projection extends to 50 years, with demographic information obtained at annual intervals. All simulations were conducted using *RAMAS METAPOP* version 5.02 (2007).

Figure 1. Risk of terminal population quasi-extinction, with associated 95% confidence intervals, across a suite of PVA model scenarios describing underlying demographic performance (defined by long-term expected growth rate λ), intensity of augmentation efforts (thousands of females) during the first 5 years of the simulated reintroduction program, and presence or absence of habitat invasion by giant river cane. Initial population size for this set of simulations is 100,000 females. Terminal quasi-extinction is defined here as the probability of the population size at the end of the 50-year simulation being lower than the initial size.



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APPENDIX J
COMMENTS ON THE 2007 DRAFT REVISED RECOVERY PLAN

Response to Comments
Rio Grande Silvery Minnow
Draft Revised Recovery Plan

The Draft Revised Rio Grande Silvery Minnow Recovery Plan was made available for review for 90 days, from January 18 to April 18, 2007. Comments were solicited from the public through a January 18 Federal Register notice; via over 700 postcards to biologists, agencies, stakeholders, and other potentially interested parties; in news releases; and on the U.S. Fish and Wildlife Service's New Mexico Ecological Services Field Office website. The Service also mailed copies of the draft plan to the governors of the 13 Rio Grande Pueblos and solicited peer review from a list of reviewers supplied by the Rio Grande Silvery Minnow Recovery Team. The following summarizes comments received and the resultant edits to the recovery plan.

PEER REVIEW COMMENTS

We requested review of the plan by five peer reviewers (Dr. Kenneth Knox, Colorado State Engineer; Stephen T. Ross, University of Southern Mississippi; Dr. Anthony Echelle, Oklahoma State University; Dr. Keith Gido, Kansas State University; and David Galat, USGS/University of Missouri). We received comments from Anthony Echelle, Keith Gido, and David Galat.

Peer Review Comments

Tony Echelle:

A1: On page 7, section 1.4 it is stated that, "Spawning by Rio Grande silvery minnow is associated with high-flow events such as spring runoff or summer rainstorms, and typically occurs over a relatively brief period (1 month) in Mayor June, although spawning can occur later in the season."

Studies by Gene Wilde's group at Texas Tech University have found evidence of continuous spawning between April and September in three species *(Macrhybopsis tetranema, Notropis girardi,* and *N. buccula)* of the reproductive guild that includes RGSM. The studies are the following:

T. Bonner. 2000. Life history and reproductive ecology of the Arkansas River shiner and peppered chub in the Canadian River, Texas and New Mexico. Ph.D. Diss., Texas Tech Univ., Lubbock

Bart Durham, Texas Tech Univ. (pers. comm.) part of his forthcoming Ph.D. dissertation that includes reproductive biology of Smalleye Shiner (*N. buccula*) in the Brazos River.

Those results are based on histological study of ovaries and back-calculations of time of

spawning from otolith estimates of the age of young-of-year individuals. There was no evidence that spawning was limited to peak flooding, but there was an association between periods of no-flow and lack of reproductive activity. A conclusion from this work is that extended periods of no-flow is the primary problem for spawning and recruitment.

Section 1.4 does not need much changing, primarily because the above-mentioned studies have not specifically dealt with RGSM. However, it has long been assumed that the various members of this guild require peak floods for spawning, and this seems not to be the case-at least for the three species looked at by the Texas Tech group. The conclusions for RGSM are based mainly on a different methodology (capture of drifting eggs), which might be biased toward detecting spawning only during peak floods. The recovery plan might simply cite Bonner's thesis for an alternative to the traditional view of factors affecting spawning in this reproductive guild.

Response: The recovery team agrees that spawning can occur throughout the season and is not limited to peak flooding although increased discharge correlates with recruitment (Dudley and Platania 2008). Gravid females late in the season and increased egg captures following summer monsoons have been observed. However, the relative contribution of these reproductive events to the population is believed to be small. The plan has been revised to indicate that spawning can occur over longer periods and in association with increased flows.

We also agree that periods of low or no flow are extremely detrimental to recruitment. Dudley and Platania (2005 and 2006) have identified several significant relationships between October catch rates and hydraulic variables. The number of days flows were <200 cfs at San Marcial were significantly and negatively correlated with October catch (r^2=0.92, p<0.001). *This information has been added to the Recovery Plan in Section 1.5.*

A2: The genetics section clearly demonstrates that the population has undergone severe bottlenecking and associated loss of genetic diversity. The genetics data also demonstrate the need for caution when captive stocks are used to augment natural populations. It is easy to propagate numbers, but it takes planning and design and dedication to appropriate protocols to maintain high genetic diversity in broodstock and their progeny.

Response: We agree. This Service regularly convenes members of the Rio Grande silvery minnow captive propagation community to plan and refine propagation strategies. The Service recently finalized the "Rio Grande Silvery Minnows Genetics Management and Propagation Plan" and expects to update this plan routinely, as needed.

A3: One concern is that Recovery Objective 1-B assumes maintenance of a captive population of 50,000 to 100,000 fish is sufficient to prevent extinction. I don't think this is what the recovery team means to imply, since Recovery Goal 1 is to prevent extinction in the Middle Rio Grande. It seems to me that Objective I-B might read, "Maintain one or more captive populations of 50,000 to 100,000 fish of sufficient quality to allow augmentation or re-establishment of wild populations."

Response: The criterion has been revised.

A4: Finally, the conditions for downlisting and delisting seem appropriate, although I worry about the 5-year or 10-year stipulations without any qualification. It seems that there should be some mention of the prospects for the continuation of the trend into the future. Populations might have done well for 10 years, but still remain tenuous because of continuing human population growth and future water development plans.

It seems especially critical that, as stated in the draft plan, downlisting or delisting will be considered only after wild, self-sustaining populations have been established in the historic range, but outside of the Middle Rio Grande.

Response: The recovery criteria have been revised and resubmitted for public and peer review. Comments on these changes and their responses are included at the end of this document.

David Galat:

Bl: Pgs 8-9. 1.4.3 Habitat Preferences. Use often 'preference'. 'Preference' has a specific meaning in that you demonstrate that fish are selecting the habitat from all possible options. This is generally demonstrated in lab studies where for e. g., fish select a temp when placed in a gradient from lethal hot to lethal cold temps. Where a fish is found in the field is habitat "use" and if this use info use is compared to habitat availability (i.e., the proportion of each habitat type available) this is termed 'selection'. I'd prefer to be on a beach in Mexico, (but it's not available just now); I can selected from locations in Columbia, MO (available habitats); and, I'm using a chair in my study. Seldom do we determine habitat preference for a species, generally its use and when companion studies of habitat availability are conducted then selection can be determined as: % used/total amount available. I suggest replacing 'preference' with 'selection' or 'use' where appropriate throughout the text.

Response: The term "Habitat Preference" has been changed to "Habitat Use" throughout the text.

B2: Pgs 5 and 6. 1.5.2.3 Population Trends: 1993 to 2004. Be careful not to equate 'population' to 'catch rates' in text and Figure 5. Population is the number of individuals out there and is usually determined by mark-recapture or removal studies and population models. 'Catch rates' (i.e., CPUE) are the number of fish collected on a particular date and time adjusted for gear effort. You are inferring in the headings population trends from catch rate data presented in text and this could be challenged. Catch rates are highly variable depending on gear, skill of personnel, weather, time of year etc. and therefore might not reflect true population trends. I suggest using the accurate term 'catch rates' in headings and not population trends, or if you insist on using 'population', state that you are inferring population trends from catch rates and be prepared to defend it. I recommend you consider undertaking short-term removal sampling as the most benign approach for actual population estimation in a monitoring plan (please see recommendation on recovery actions below).

The data generated from this approach would be enable continuing the multiple year CPUE comparison currently being done, but also permit a more rigorous population estimation that

could over time supplant CPUE. Recovery goals are stated in terms of population not CPUE, so it would be worth the added cost and time to actually measure success criteria rather than a surrogate.

Response: We have added text to the beginning of the section titled "Population Trends: 1993 to 2004" (now updated to include through 2008) that describe the assumptions inherent in using CPUE data to infer population trends. While we agree that the numbers collected are not an absolute measure of population size, catch rates are proportional to the total population and therefore a reliable estimator of spatial and temporal variation in abundance.

Studies are currently underway to develop a population estimate for the silvery minnow (Dudley et al. 2009). The methodology was developed through a peer review process funded by the Middle Rio Grande Collaborative Program (Pap report, unpublished) and uses a spatially balanced General Random Tessellation Stratified sampling and depletion sampling. This project also tested sampling efficiencies for various habitats and sampling methods to allow more refined extrapolations from CPUE to abundance.

B3: Recruitment and Flow. There is much anecdotal information herein relating successful recruitment of RG silvery minnow to flow pulses. However, I did not see any quantitative analyses testing this (e.g., testing CPUE among years against flow, showing year-class strength was higher in years with flow pulses than for those without. Multivariate analyses demonstrating that flow was an environmental explaining a significant amount of variability in minnow CPUE, etc). Currently there are two competing models addressing how flow influences recruitment of small, riverine fishes. Harris and Gehrke (1994) proposed the 'flood recruitment model' which has been generalized in the "natural flow regime" (Poff et al. 1997) to describe how some species respond to changes in flow and flooding. This model implies flow initiates spawning and places emphasis on the role of the floodplain (Humphries et a1. 1999). Many riverine species have been thought to be dependent on flow and/or temperature changes, thereby placing them in the 'flood recruitment model.' However, many riverine fishes do not depend on the-floodplain for successful recruitment (Galat and Zweimiiller 2001) and the evidence appears equivocal if RGSM does or does not require floodplain nursery areas. Recent research (Humphries et a1. 1999, Humphries et a1. 2002) questions universal applicability of the flood recruitment model for riverine fishes. In contrast to the flood recruitment model, some species can have successful recruitment during low flows. Humphries et a1. (1999) proposed the 'low flow recruitment hypothesis' to explain how some native species in the Murry-Darling River, Australia, are able to successfully spawn during periods of low flow. This hypothesis suggests some species take advantage of low flows to spawn because appropriately sized prey is concentrated and abundant (Humphries et a1. 1999). This is not the 'very low' flows discussed in the recovery plan but the typically seasonal low flows that occur following the annual flow pulse in many arid-zone rivers.

Response: Dudley and Platania (2008) identified significant relationships between October catch rates and hydraulic variables associated with peak discharge. October catch rates increased significantly with number of days discharge at the Albuquerque gage exceeded 3,000 cfs ($r=0.91$, $p<0.005$) and with the number of days discharge exceeded 2,000 cfs at San Marcial ($r=0.90$, $p<0.001$). We have revised section 1.4.2 to include this information.

B4: It is tempting to adhere to the flood-pulse dogma for RGSM, particularly because of their pelagic spawning mode --but contrary models exist. I'd like to see a more multiple hypothesis approach to quantitative analyses of what suite of environmental factors (e.g., photoperiod and temperature are universally recognized as the primary environmental factors that determine spawning timing of all teleost fishes) are most highly correlated with successful RGSM recruitment. This uncertainty is addressed in Recovery action 1.1., so l'd be less confident here of the role of flow if you acknowledge on page 75 that its role as a spawning trigger is not well established.

Response: Recovery action 1.1.1 recognizes that further work on the relationship of different environmental factors is needed. We have revised the text in Section 1.4.2 to clarify that while flow strongly correlates with spawning, additional work is needed to more fully understand mechanisms.

B5: Pg 67 and subsequent pages. The text: "Document sub-populations of an estimated - minimum 500,000 unmarked fish each (with an assumed effective population size of 500) in the Angostura and Isleta reaches of the middle Rio Grande during October, and an estimated minimum sub-population of 100,000 in the San Acacia Reach; these may also be defined as sub-populations in which the lower boundary of a 95 percent confidence interval of October catch per unit effort (CPUE) data from all sites within each reach is > 1 fish/100 m^2."

I'm not clear what is meant by these sub-populations of unmarked fish and what is meant by, effective population size or how this is determined? Pg 20 discusses estimates of effective population size, but I did not see a conclusion of how the target was determined or justified? This relates to my previous comments on equating CPUE with populations. Appendix H was Acronyms, not the standard annual sampling protocol indicted in text. I could not locate this information in the Recovery Plan.

Response: The criteria have been revised (see response to comment A4). Appendices have been labeled correctly.

B6. Pg 67. Recovery Goal 2: Define what constitutes a "self-sustaining population" in quantitative terms. The present definition (see below) is not measurable given that no sustained population level is defined or how it might be defined is not described. The definition is circular in that it defines a self-sustaining population as a sustained population level! Currently this objective is not completely SMART -specific, measurable, achievable, relevant, and time-dependent.

Response: The criteria have been revised (see response to comment A4).

B7. Pg 68. Recovery Criteria *3-A-2* and elsewhere. "Annual reproduction in all three populations, as indicated by the presence of young-of-year, for ten consecutive years." It seems unrealistic to this reviewer to require successful reproduction for 10 consecutive years given the climatic variability in the Southwest and likely drought cycles that existed before river regulation. What evidence is there that RGSM exhibited successful recruitment every year during a decade before river changes? Is this objective achievable? I suggest a more realistic

target of x of y years (e.g., 8 of 10 years or 13 of 15 years -these are not recommendations, only examples) that takes into account regional climatic variability unrelated to river operations.

Response: The criteria have been revised (see response to comment A4).

B8: The current Recovery Actions read like a laundry list of research needs and resources will unlikely be available to accomplish all. I suggest each action be linked back to a recovery objective and criteria and that the relative strength of accomplishing this be used to prioritize actions.

Response: Table 5.1 links each Recovery Action to the threat it will help alleviate. The team deliberately developed a comprehensive set of recovery actions (to be used as a toolbox) rather than a prescriptive set of activities. This approach allowed the team to include actions that may be politically or legally challenging without resolving those issues in the plan. We agree that resources will not be available to implement every action, nor do we believe implementing every action will be necessary. Given the dynamic nature of the ecosystem, legal authorities, and stakeholder interest, some actions that may be prohibitively expensive or infeasible in the short term may become more cost effective or possible later in time. Recovery Action 4.3 has been revised to encourage the development of a recovery action plan that would annually prioritize actions.

B9: Lastly, I recommend that a structured decision process be developed for updating recovery goal setting as outlined in Tear et al. (2005) and that you incorporate all or most of the 15 guidelines for effective science and 15 for effective use of that science into RGSM recovery as outlined in Van Cleve et al. (2006).

Response: We agree. We plan to incorporate adaptive management and hypothesis testing throughout the recovery process. Structured decision-making may be a critical component of such adaptive management with PVA modeling and other tools informing the process.

Keith Gido:

CI: A considerable amount of work went into synthesizing this information, which, as I understand it, will help guide the recovery of this species. Given the importance of understanding the ecology of RGSM in these recovery efforts, I suggest explicit statement that identify where there are gaps in our understanding of its ecology. This will not only help qualify interpretations of weak data sets, but also identify those areas to potentially focus research efforts.

Response: Text has been revised considerably to include recognition of knowledge gaps in silvery minnow biology and ecology.

C2. S1.4.2:P8, line1 - Change "Spawning results in high mortality of Rio Grande silvery minnow." to "Mortality of juvenile Rio Grande silvery minnow is high." This seems to infer that spawning is the cause of mortality.

Response: This section has been revised to improve clarity.

C3. S1.4.2: P8, last paragraph - It would be helpful to mention how the maximum age was determined, as some methods can be biased.

Response: Additional information about maximum observed ages of silvery minnow (and the assumptions and biases of different aging methods) has been added to Section 1.4.2

C4. S1.4.3 - second paragraph, first sentence. Qualify that "juvenile and adult" RGSM use only a small portion of the available habitat. Drifting eggs and larvae likely use the entire river.

Response: The text has been revised as recommended.

C5. S1.4.7, 1st paragraph - Perhaps clarify what is meant by "hatchery-reared, wild-produced". It also would be helpful to give the number of marked fish released and recovered.

Response: The text has been revised to clarify that the fish were reared in the hatchery from wild caught eggs. Numbers from the study have been added, as well as information from a recently completed movement study (Remshardt 2008b).

C6. S1.5.2. Why is the increase in rank abundance between 2003 and 2004 singled out from the long-term data in this section? This seems like a trivial point, given the strong pattern of decline in CPUE shown in Figure 5. That is, the increase in absolute abundance as estimated by CPUE from 2003 to 2004 is only a difference of less than 1 fish per 100 m^2, whereas the difference between 1993 and 2004 is > 10 fish per 100 m^2: In addition, rank abundance is dependent of other species in the assemblages. Thus, the ranked abundance of a species (e.g., RGSM) can increase because its population size has increased or because populations of other species have declined.

Response: The plan used 2004 information because it was the most current at the time the draft was completed. We have updated this section to discuss trends and patterns in the complete set of data rather than focusing on one year

C7. S1.5.2.6, 4th paragraph - A sentence clearly acknowledging that the long-term response of RGSM populations to flows is not well understood seems necessary here.

Response: Please see response to comment B4.

C8. S1.5.2.6, last sentence, P19 - Although this sentence is qualified, I suggest refraining any inference of patterns in 2005 without data. And, if data are present not making too much out of a single year without further justification.

Response: Please see response to comment C6 and C7.

C9. 3.2 Recovery Criteria I-A-I -I see the merit in selecting both criteria of population size and spatial distribution as criteria to prevent the extinction of RGSM. However, I'm not convinced

these should be exclusive. That is, it seems more appropriate to designate a minimum distributional extent (e.g., ~ of all sites) AND population size (e.g., 500,000 individuals). My greatest concern is with the ability to attain accurate population estimates and the uncertainty in interpreting how that is associated with the health of the overall population. Even if this were possible, high densities in a restricted area should be much more vulnerable to extinction than more broadly distributed populations.

Also, what is the justification for a 5-year time interval? Given the response of this fish to hydrology, it seems logical to use hydrological records to determine the time interval that is necessary to indicate the species can endure extreme fluctuations. As an example, I have downloaded annual mean discharge data from the USGS gauging site at Otowi Bridge (see graph below). After applying a 3-year running average to those data is seems clear that hydrologic cycles occur in greater intervals than 5 years. It is also not unreasonable to get 5 or more consecutive years with high discharge. Biologically meaningful criteria for downlisting would be to include both high and low discharge years. It appears that 10-15 years is necessary for this to occur.

Response: The recovery criteria have been revised and resubmitted for public and peer review (see response to comment A4).

PUBLIC REVIEW COMMENTS:

The Service received 11 comment letters identifying a total of 72 significant issues which are presented and responded to below. Comments are organized by document section. Comments related to formatting, style, and general edits are not repeated here, but were incorporated into the final document, where appropriate. A complete set of all letters received are available for review at the New Mexico Ecological Services Field Office.

General/Executive Summary

1. One commenter recommended the formation of oversight committee for the purpose of conducting annual and five year progress reviews on accomplishment and achievement of recovery actions. This committee would provide a brief report to the recovery team and the MRGESCP Executive Committee to evaluate recovery progress and help steer MRGESCP in its efforts and the recovery team in the 5-year evaluation of the recovery plan.

   Response: The Service conducts annual reviews of progress toward recovery and a status review (including the recovery plan) every five years. This review is conducted in coordination with our partners and would include all stakeholders who participated in developing the recovery plan and who assist with implementation efforts. We agree that communication and coordination with the MRGESCP is essential to the success of this recovery effort but believe a separate committee would be redundant to the process.

2. One commenter recommended editing the plan into one of 50 pages or less.

Response: The Service appreciates all the support provided by our partners in developing the draft plan. Through the incorporation of public and peer review comments we believe the readability and clarity of the plan has been greatly improved. While we agree that a shorter plan might be more digestible, because recovery plans are used as a single source of information on the species, its threats, and its recovery status, we do not agree that excising large portions of the plan would be beneficial and may undermine the overall value of the document.

3. Page vi, Estimated Cost of Recovery: It was suggested that the estimated cost is not well justified in the text of the document. It would benefit from rigorous review and refinement so that technically defensible costs for designing, implementing, and completing each of the defined actions are developed.

   Response: The costs for individual recovery actions have been updated, leading to a revised total of $167,500,000. These costs follow actual costs for actions already underway, as well as estimates provided in the MRGESCP Long Term Plan. A sentence explaining how costs were derived has been added to introduction to Section 6.0. These costs are estimates, however, and are expected to change depending on the year and manner in which different actions are implemented.

4. Page vi, Date of Recovery: It was suggested that the date of recovery should be better justified and include estimated times when stated goals are to be achieved and population response is expected. It should also be linked to restoration of existing population, establishment of new populations, anticipated time to achieve minimum viable population size or genetic effective population size.

   Response: The estimated time to recovery is based on our assessment of the time needed to develop and publish rules allowing reintroduction as well as the time necessary to establish new populations. The timeframes are estimates, however, and may, in reality, be longer or shorter than anticipated. As recovery plans are guidance documents, these timeframes are intended only as guidance to assist with planning. Additionally, this recovery plan will be reviewed and updated regularly.

5. A comment was made that since the Middle Rio Grande Collaborative Program is funded, active, will likely have congressional authorization, and the goal of the Program is to support recovery of the Rio Grande silvery minnow, the recovery plan should allow for separate downlisting and delisting of the Middle Rio Grande silvery minnow population. This may require designation of the silvery minnow population in the middle Rio Grande as a "distinct population segment." This would provide considerable incentive to the participants in the Middle Rio Grande Collaborative Program to vigorously pursue those activities needed to downlist and delist the silvery minnow within the middle Rio Grande.

   Response: The ESA requires the recovery of listed entities. Since the entire species of Rio Grande silvery minnow (not a distinct population segment or a significant portion of the range) was listed in 1994, delisting could only occur at the species level. It is also logically impossible to argue that this population is discrete and distinct from other populations

(required to meet designate a population as representing a significant portion of the range) since it is currently the only reproducing wild population; it represents the only secure range, not a portion. The recovery team recognized that the species could not be recovered solely within the Middle Rio Grande in New Mexico. For this reason, additional populations are needed for full recovery.

6. Several comments argued that the recovery plan does not adequately recognize the importance of the Middle Rio Grande Collaborative Program and suggest that activities and priorities defined in the Collaborative Program's Long Term Plan be reflected in the recovery plan.

   Response: The plan recognizes the collaborative program as the critical entity for implementing recovery for the silvery minnow in New Mexico. A discussion of the collaborative program and its role in conservation of the species has been added to Section 1.10. Language has been added to Section 4.0 to emphasize its role and the importance of certain recovery activities for the middle Rio Grande population. Because the recovery plan is broader than the middle Rio Grande and the collaborative program area, we recommend the collaborative program update its long-term plan to reflect the priorities of the recovery plan once the recovery plan is final.

7. One commenter recommended restating "Prevent the extinction of the Rio Grande silvery minnow in the Middle Rio Grande of New Mexico" as "Ensure survival of the Rio Grande silvery minnow in the Middle Rio Grande of New Mexico."

   Response: The referenced wording was chosen by the recovery team to focus on the immediate plight of the species within its occupied range. The proposed statement is equivalent to this since to prevent extinction also ensure survival. The recommended change was not made.

Background

8. General statement on Section 1. There appears to be an incomplete review of pertinent literature on Rio Grande silvery minnow. It appears some recent publications have not been reference or cited. One example is the paper written by Dr. David Cowley and others in 2003 entitled "Ecology of the Rio Grande Silvery Minnow Inferred from Specimens Collected in 1874".

   Response: The text and accompanying literature in Section 1 (and throughout the plan) have been updated to include current relevant citations. Discussion of the results of Cowley et al. (2003) has been added to section 1.4.2.

9. Page 7. The draft plan should provide a wider time range for the occurrence of spawning (discussed as May/June in the plan) given information documenting spawning from mid-April through mid-July 2006 and observations since 2000 of spawning occurring in late April. The potential for climatic warming affecting timing of snow melt runoff and spawning may also be of importance and could be critical in low water years.

   Response: The referenced sentence has been revised to acknowledge the potential for spawning earlier in the year.

10. Page 7, § 1.4.2: The description of egg drift gives the impression that eggs and larvae of RGSM are always transported great distances downstream. There is substantial scientific information in drift studies conducted in the Pecos River, Rio Grande, and Green Rivers that cast substantial question on the ongoing paradigm that demersal eggs and larvae of RGSM always drift great distances downstream. Depending on river flow, channel size and bank diversity, most beads and larvae are entrained in the first 50-75 miles from their point of origin.

    Response. This section has revised to clarify that egg drift is a function of both flow and channel morphology.

11. Page 9, 1.4.7: This brief paragraph on movement based on Platania et al (2003) appears to be offered as the biological basis for later recommending $15 million in structural fish passage work as part of recovery.

    Response: The Recovery Team recommended fish passage to alleviate the effects of fragmentation (Listing Factor A, Water Impoundment). Passage is needed to alleviate the genetic effects of unidirectional dispersal (downstream).

12. It is interesting to note that Wesche's 2006 statistical analysis of fish monitoring data comparing the seasonal distribution of RGSM below San Acacia Dam found no strong evidence of fish being in greater abundance immediately below the structure. Non-structural passage enhancement alternatives, including "collect and relocate," should be considered before dedicating large fund expenditures. Alternatively, more emphasis should be given

diversion structure re-design to allow up- and downstream passage than relying almost completely on constructing fish passageways.

Response: Fish passage is recommended by the Recovery Team to alleviate the effects of fragmentation and ongoing loss of genetic variability from upstream reaches. The commenter suggests silvery minnows need to congregate below the dam in large numbers to justify the action. However, small numbers of individuals passing the dam from downstream to upstream can facilitate critical genetic exchange, which does not currently occur naturally in the upstream direction between fragmented reaches. We agree that alternatives to fish passageways should be considered; however, a non-structural, collect and relocate program would be insufficient to meet the recovery goal of establishing self-sustaining populations. Recovery for the Rio Grande silvery minnow is tied to specific criteria, which include the establishment of self-sustaining populations. Management that requires continual human intervention, such as a collect and relocate program, would not allow for the population to become self-sustaining in the wild.

13. Page 9, 1.4.4: The statement here regarding RGSM use of main channel runs is contradictory of the habitat discussion presented at the bottom of page 8.

    Response: We disagree. The statement indicates that silvery minnow are found in a broad spectrum of habitat types, but found most commonly in low velocity areas. This section has been expanded to improve clarity.

14. Page 9, 1.4.5: Is the reported seasonal shift to deeper habitats due to higher flow conditions or a true shift in preference? How can boulder habitats be seined effectively to make the statement that RGSM do not utilize such a substrate?

    Response: All references to "preference" have been changed to reflect occupancy or use. Dudley and Platania use the modified Wentworth classification for substrate particle size (from Cummins, K.W. 1962. Evaluation of some techniques for the collection and analysis of benthic samples with special emphasis on lotic waters. American Midland Naturalist 67:477-504.). Under this classification boulders are > 256 mm in diameter (i.e., 10 inches). Such habitats can be seined effectively. Most 'boulders' encountered by Dudley and Platania were 10-16 inches in diameter. The text has been revised to indicate that boulders were "small" and rarely found. Note: Additional information has been added to this section.

15. Several commenters noted that catch rate/population trend data should be updated to include recent years.

    Response: The recovery plan has been updated to include new references and population data through October 2008.

16. Any study results or other information regarding the survival of salvaged silvery minnows (section 1.10.5) is a critical piece of the recovery plan. This research will help determine the value of rescue and salvage activities to the survival and recovery of the silvery minnow,

especially since as recently as 2003 it was "unknown what effect salvage operations have on silvery minnow survival." March 17, 2003 Biological Opinion at 72.

Response: This information has been added to section 1.10.5.

17. The IHA analysis (Wesche et al. 2005) found that at San Marcial, median spring high flows have substantially increased and low flows have stayed about the same in the post-Cochiti period when compared to the pre-Cochiti period. The number of zero flow days has declined here when the recent period is compared with the 1899-1935 period. At Albuquerque, high flow magnitude and duration have increased substantially in the post-Cochiti period, while most low flow characteristics have also been increased. The facts regarding stream flow alteration simply do not support the speculations presented here. Here, the team intimates that increased magnitude, frequency and duration of low flows is at least partially responsible for the decline of habitat quality and the RGSM, while the low flow correlations of Dudley et al suggest just the opposite. Following the logic of both the team and Dudley et al (2005), the enhanced high flow regime experienced in the post-Cochiti period should have positively affected the RGSM, but apparently has not.

Response: The recovery plan acknowledges that hydrologic alterations have changed flows within the middle Rio Grande. The plan discusses in great detail the fact that upstream storage, and downstream releases for agriculture and other uses have severely changed the timing, duration, and distribution of water throughout the year. We disagree, however, that these changes may be considered "enhanced" with regard to the silvery minnow or that river flow can be evaluated in isolation. The hydrograph Dr. Wesche examined compared gauge data from the early period of record (when very substantial alteration had already occurred) with modern regimes. Typically, IHA is used to determine pre-alteration hydrography. What we can infer from aerial photographs and historical accounts is that the formation of overbank areas, backwaters and slackwaters, all critical components of silvery minnow recruitment habitat, was more readily available pre-Cochiti. That lower flows sustained the silvery minnow in historic times is not surprising. The installation of Cochiti, flood control levees, jetty jacks, and other flood control structures, combined with increased groundwater withdrawals have modified the river's morphology to the point where ever higher peak flows are needed to inundate critical habitat.

Dudley et al. (2005) compared silvery minnow population dynamics under existing conditions to determine which factors best predict successful recruitment in the current middle Rio Grande. They found that sustained spring runoff and minimal levels of intermittency correlated positively with recruitment. Additional information on the methodology of this study and subsequent reports has been added to Section 1.5.2.2.

18. Also, the IHA analysis found that the date of the annual maximum flow has been about 30 days earlier in the post-Cochiti period (Wesche et al, 2005). How might this earlier peak, and its potential effects on water temperature, influence spawning success and timing?

Response: Earlier peaks would likely adversely affect spawning success since water temperatures would be lower than optimal. The recovery team has recommended further

research into these relationships to better determine the water management actions that would improve spawning and recruitment conditions for the silvery minnow.

19. Section 1.7.2. It should be specifically noted that, based on the Service's own documents (March 2005), the Service believes the silvery minnow has been extirpated in the Rio Grande above Cochiti Reservoir.

    Response: This information has been added and the referenced study included in the discussion as recommended. Additionally, the legend for Figure 6 has been revised to clarify that the currently occupied range of the silvery minnow does not extend above Cochiti Dam

20. Page 22, 1st full bullet: Ecologically, what is the significance of plains minnow out-competing the RGSM in the Pecos River?

    Response: Due to several causes, the Rio Grande silvery minnow has been extirpated from the Pecos River and the other locations listed on page 27. The ecological significance of the plains minnow outcompeting the Rio Grande silvery minnow in the Pecos River is the extirpation of the Rio Grande silvery minnow from that portion of its historical habitat. As a result of these extirpations, the species is now confined to approximately seven percent of its historic range. This reduced range and significant threats to the species in its remaining habitat are the reasons the Rio Grande silvery minnow was listed as endangered in 1994. Competition and/or hybridization with non-native introduced species such as the plains minnow also has the potential to affect these remaining extant populations of Rio Grande silvery minnow; however, the degree and extent of this threat is not fully understood.

21. Page 23, Listing Factor A: This list is quite repetitious and in some cases conflicting. For example, "annual dewatering," "altered flow regimes," "prolonged summer base flows," "reduced flows," and "creation...of altered flow regimes" all appear in the list suggesting some re-organization and editing is needed. Supporting literature should be provided for each of the factors listed and conflicts such as between "prolonged summer base flows" and "reduced flows" need to be reconciled. A shopping list such as this leads one to think the team does not realize that river flow is inherently variable and that humans are also part of the hydrologic equation.

    Response: *The purpose of Section 1.7 is to summarize the reasons for listing based on the threats assessment and update the threats to identify any changes to the severity or relevance of those threats. The list referenced in the comment is taken directly from the Federal Register notice (50 CFR Part 17).*

22. The final paragraph here (suggesting that the silvery minnow continues to be threatened with extinction) is shear speculation and alarmist rhetoric that should be deleted.

    Response: We disagree. The U.S. Fish and Wildlife Service based its listing decision, in part, on its limited distribution and declining abundance within the occupied range. Threats to the species and its habitat indicated that it could be expected to become extinct in the foreseeable future. While some of these threats to the silvery minnow have, in some

circumstances, been reduced they have not yet been removed. The cumulative effects of several consecutive years of river drying, downstream displacement, and habitat degradation continue to affect the status of the silvery minnow. The silvery minnow has, at times during the last 20 years been highly abundant in selected reaches of the middle Rio Grande, its numbers have also been extremely low in recent years. Threats to the species remain.

23. Page 25. How could RGSM survive during drought and channel drying in areas of irrigation return before diversions dams (and thus irrigation)? Realize Native Americans practiced irrigation before arrival of Europeans, but their infrastructure was different and did not divert quantities typical of European-style irrigation. Key difference is that before European diversions, fish movement was not impeded by diversion dams and fish had access to refugia and could repopulate dewatered reaches.

    Response: This discussion has been expanded to include additional relevant information about habitat quality and habitat fragmentation.

24. Page 26. How much more work/research is necessary to demonstrate that larval fish are entrained by irrigation diversions into canal system? Entrainment in irrigation diversions should be included as factor contributing to decline

    Response: That larval fish and eggs are entrained is not in dispute. However, a more thorough knowledge of the conditions under which entrainment is more or less likely can assist with developing appropriate management strategies. This discussion has been moved to follow Actions 2.1.4 and 2.1.

25. Page 27. What is relevance of levee breaching in section on impoundments?

    Response: Flood control reservoirs are designed to minimize the potential for flooding of developed lands. When levees are in danger of being breached, peak flows are reduced as flood waters are held in reservoirs. As is discussed in the following paragraph, this type of flow modification can adversely affect silvery minnow recruitment when floodplain habitat fails to inundate or when flows are rapidly reduced, stranding fish in overbank areas.

26. Page 27. How water is moved around among reservoirs is not relevant to this section.

    Response: We disagree. The management of water through impoundments directly influences the flow regime, both during storage, by reducing peak flows, and during release as spring flows may be enhanced and winter flows increased over what might otherwise be observed in the system.

27. Range fragmentation is more than 'suspected' as factor contributing to decline of RGSM. It has been demonstrated. Several published papers on RGSM genetics clearly demonstrate range fragmentation contributed to decline.

    Response: We agree. This section has been updated with recent genetics information.

28. Page 28. How could cities and agriculture not affect water quality?

Response: Text in this section has been updated to include specific and new information about the relationship between water quality and fish health and the sources of adverse water quality conditions (if known).

29. Page 28. Throughout these sections, the use of qualifiers (suspect, may, dearth of information) to soften reality are bothersome and disingenuous. If the overwhelming body of evidence indicates one thing, or if common sense strongly supports, then a simple statement that such and such occurs is warranted.

Response: These qualifiers were contained in the original listing package (59 FR 36988) to indicate the limits of our knowledge at the time. This section has been updated to address numerous comments indicating the need to reflect more current information.

30. Page 28. Where and when have elevated winter flows occurred and who has documented the negative effects?

Response: The Bureau of Reclamation routinely evacuates unused contract water and by statute/regulation this typically occurs during the winter months. How elevated flows modify silvery minnow habitat is discussed in Section 1.7.5.3.

31. Page 28: In the 1st paragraph, the statement about RGSM not persisting in the ditches or LFCC contradicts the Bureau findings reported on page 26. Most statements made throughout this page need literature support.

Response: We disagree. To clarify, eggs are entrained in irrigation structures and adult silvery minnow are occasionally observed in them. Nevertheless, the habitat in the irrigation ditches does not provide the necessary conditions for long-term survival or recruitment. Clarifications and additional citations have been added to this section.

32. Page 29. In the 4th paragraph, if the present collection methods used for fish monitoring are so inefficient, why does the program continue to fund such an effort and give credibility to the results obtained?

Response: This section refers specifically to collections of museum specimens, not silvery minnow population monitoring. Note, this paragraph has been revised for clarity and updated to reflect the limits placed on scientific collections.

33. Page 30, 5th paragraph: How have avian predator numbers changed in recent years? Based on our observations along the middle Rio Grande and its system of drains and canals, we don't believe this effect should be so lightly dismissed.

Response: This effect is not dismissed, only noted as unquantified. Indeed, the recovery team recommends further study on the effects of competition and predation on silvery minnow populations (please see Recovery Action 1.5)

34. 1.7.8 -No protection of Rio Grande silvery minnow habitat under state law (p.30): "However, the protection afforded to species by the state does not extend to the habitat upon which the species depends." It is unclear what additional protection under state law could occur to in-channel habitat of the silvery minnow. Channel modifications are regulated and controlled under Section 404 of the Federal Clean Water Act.

    Response: During the listing process, the Service evaluates threats to the species using the "five factor threats analysis;" the adequacy of existing laws and regulatory mechanisms to protect the species is one of the factors evaluated. While channel modifications may be regulated under existing law, channel modifications are only one of many habitat-related threats to the species. Other threats include dewatering and diversion, water impoundment, river modification, and water pollution. The Service determined that in the absence of federal protection, few regulatory mechanisms exist to adequately reduce these threats (59 FR 36988).

35. 1.7.8.2 - Instream water rights for fish and wildlife (p.31): It appears that the state engineer has adequate authority to protect instream flows that might be provided for silvery minnow. This should therefore be removed from this section or clarified as the opinions state that there are no legal impediments to these, but there may be significant challenges or obstacles to actually obtaining water solely for this purpose. Note, the State Engineer has granted water right permits for instream flows on both the Pecos River (to increase water flows for the threatened Pecos bluntnose shiner) and the Rio Grande (to increase water flows for the endangered Rio Grande silvery minnow).

    Response: This discussion has been updated to reflect recently issued opinions clarifying the State Engineer's authority.

36. 1.7.8.3 – Inadequate regulations to restrict the use of bait fish (p.31): This no longer appears to be a factor. The concern is based on past practices and practices that are now illegal. It appears that the regulation is adequate, given that these practices are illegal.

    Response: A sentence has been added to this section to note that despite the potential for adverse effects from illegal use of non-native bait fish, existing regulatory mechanisms are adequate.

37. 1.7.9.2 – Competition with nonnative fish (p.32): The information provided is unclear regarding whether or not this is a problem in the Middle Rio Grande.

    Response: Competition is difficult to document and as yet, has not been systematically investigated in the Rio Grande for possible effects on the silvery minnow. The recovery team has recommended competition and predation studies (see Recovery Action 1.5) to better inform the extent of this threat and whether management of exotics or predators would be appropriate. Text has been added to the recovery plan to clarify that the degree to which competition with non-native fish is a threat to silvery minnow is not known.

38. 1.7.9.1 – Reduced population numbers and potential loss to genetic diversity (p.32): The section states that the actual effective population is about 100. There is no conclusion provided as to whether or not this is adversely affecting the species. More specifics should be added. If 100 are not adequate, what is the appropriate effective population and what is the basis for that number?

    Response: This section has been revised to reflect current information on the genetics of the silvery minnow and our understanding of the effects of low population size.

39. The Conservation Efforts section is generally well-written and informative, but a couple of sub-sections need improvement. Page 43. It would be helpful to provide specific examples of how 'Water management activities in the middle Rio Grande have advanced significantly over the past five years…'

    Response: A discussion of water efficiency and water management improvements has been added.

40. Section 1.10.3 - A number of restoration activities are being planned along the Rio Grande and its tributaries either directly for the minnow or that will create habitat for wildlife in general and will likely benefit the minnow. This includes work on Pueblo lands. Plans and projects are ongoing by numerous groups from Cochiti to Elephant Butte but are not discussed in the Draft Plan. The Okay Owingeh Pueblo habitat restoration work is not mentioned and should be. Likewise, activities in Texas or the Pecos drainage are not discussed. We suggest the draft plan be modified to incorporate such information.

    Response: This section has been updated to include restoration projects that have been completed since the Draft Revised Silvery Minnow Recovery Plan was issued. A brief discussion of planned projects has been added.

41. Section 1.11 Tribal Perspectives. Two letters commended the inclusion of this section into the Recovery Plan. One letter recommended its removal.

    Response: The Tribal subgroup of the recovery team recommended maintaining this Section in the Final Rio Grande Silvery Minnow Recovery Plan.

Recovery Criteria

Recovery Criteria have been revised in response to numerous questions and comments on the proposed criteria. Comments largely mirrored those provided by our peer reviewers by questioning the rationale for population targets and requesting more objective and measurable criteria. Repetitious comments have not been included here but are available for review as part of the administrative record. Comments and responses for the new criteria are found in Appendix X+1

42. The recovery plan should define "potential Rio Grande silvery minnow habitat." See, e.g., recovery plan at 68, 70.

Response: The text has been revised to clarity intent. It now reads: "…within occupied areas and reintroduction sites."

43. Page 67. Recovery Criteria 1-B-1. Suggest editing the "A captive population of 50,000 to 100,000 fish" to read "A captive population of 50,000 to 100,000 adult fish at each of three or more rearing and breeding facilities." As mentioned earlier, we believe the facilities in combination have the capability of safely holding more than 100,000 fish. By holding sufficient fish in each facility we ensure that the majority of the captive population is not all housed in one location that could fail. If funding gets restricted it is still important to keep up several geographically separate captive stocks. Same comment regarding Recovery Criteria 2-C-1.

    Response: The Rio Grande Silvery Minnow Genetics Management and Captive Propagation Plan (November 2007), recommends captive populations across several facilities. The Recovery Criteria follow this plan, which may be revised and updated as facilities become operational and new information is incorporated into captive programs. The criteria now reads: A captive population of 50,000 to 100,000 adult fish, held in accordance with the Rio Grande Silvery Minnow Genetics Management and Captive Propagation Plan (November 2007 and any revisions, thereto).

44. Page 68, Recovery Criteria 2-D-1. Sandia and Isleta are the only two Pueblos below Cochiti Dam that have promulgated water quality standards pursuant to the Clean Water Act. Certain criteria within these standards are not possible to attain. A specific example is Sandia Pueblo's Human Health Criteria for arsenic, which was established at 0.0175 micrograms per liter (parts per billion, or ppb). Naturally occurring arsenic in the Rio Grande in the middle Rio Grande is on the order of 3 to 4 ppb, or two orders of magnitude greater than the criteria.

    The plan's recovery criteria should only require achievement of standards relevant to the health of aquatic organisms. The State of New Mexico has designated one of the uses of the middle Rio Grande as Marginal Warmwater Aquatic Life. The Pueblos of Isleta and Sandia have designated one of the uses of their specific stream segments as Warmwater Fishery Use. The recovery criteria should require achievement of State and tribal water quality standards specific to the use of Marginal Warmwater Aquatic Life (State) or Warmwater Fishery Use (Pueblos) as well as all General Criteria (State) or General Standards (Pueblos), including the numeric criteria for Aquatic Life (State) or the Fresh Water Aquatic Life Criteria for toxic substances (Pueblos). The Pueblo's Human Health Criteria for toxic substances, which are based solely on fish consumption, should be excluded from the recovery Plan, and the State's numeric criteria for Human Health and for Domestic Water Supply should be excluded.

    Response: Criterion 2-D-1 is now 2-B-4 and does not specify particular water quality standards that must be met. The plan calls for improvements to water quality to increase reproduction and survival of existing and reintroduced populations.

45. How does a captive population contribute to recovery? A captive population is a tool. Having one should not be treated as a measurement or indicator of recovery success. Recovery is based on what is in wild, not what is in a hatchery or zoo.

Response: A captive population is critical to prevent extinction in the immediate future since the wild population is not secure. However, the comment correctly notes that a captive population is not an appropriate criterion for downlisting. Criterion 2-C has been deleted.

46. How does a non self-sustaining population contribute to recovery? Perhaps there is a rationale for letting such populations contribute to recovery, but if so, such should be detailed here. Besides, if it is not self-sustaining, it does not satisfy ESA purpose.

Response: The recovery team recognized that the middle Rio Grande population may not become self-sustaining due to persistent threats. However, protecting this population is critical to recovery. The middle Rio Grande population provides the only remaining pool of genetic diversity for the species and ensures redundancy while the species is being established elsewhere in its historic range.

47. Page 68. Achieving floodplain inundation is only possible in those subreaches of the middle Rio Grande where overbanking is possible during high spring flows. These sections have recently been identified in several studies (Massong et al. 2006, Harvey 2006). Recovery planning should be more precise regarding this criterion since floodplain inundation can only be achieved in certain discrete locations. This recovery plan should estimate the amount of recruitment that is possible at each section where floodplain inundation is possible.

Response: We agree this research is important. The MRGESCP is currently conducting reach-by-reach analyses of population dynamics, habitat availability, and opportunities for floodplain inundation and restoration. The results of these studies will inform future management actions.

Recovery Actions

48. 2.2. Provide suitable habitat for Rio Grande silvery minnow using water management strategies for the middle Rio Grande valley (p.84); it is stated elsewhere in the report (Section 2.0) that all activities listed in Section. 4.0 must be implemented to achieve recovery. Section 2.2 regarding water management strategies for the Middle Rio Grande valley lists a number of possible or potential water management activities that could be used to enhance habitat for Rio Grande silvery minnow. However, the feasibility of many of these strategies is unknown.

Response: The intent of Section 4.0 is to identify all possible actions, while recognizing that some are more feasible than others. The referenced text in Section 2.0 has been clarified.

49. Page 64. While all actions listed will contribute to recovery of RGSM, the most critical for middle RG population is provision of sufficient water for each life stage. This recovery action should not be buried. The over-arching purpose of RGSM recovery plan should be

identification and means needed to implement direct actions that contribute to recovery. Provision of water is the most critical of these and should stand above all other actions.

Response: It can be argued that water without habitat is insufficient to recovery the silvery minnow. Similarly, a population that is compromised genetically will remain vulnerable to extinction regardless of the amount of water and habitat available. The recovery team recommended the full suite of recovery actions necessary to protect and recovery the species in the middle Rio Grande and elsewhere.

50. Pages 75, 83, § 1.1.3, 2.1.4, and 2.1.5: These actions present some dialogue on "recruitment" of Rio Grande silvery minnow," but in the latter two sections, it is only expressed as "loss of recruitment" due to entrainment into either irrigation canals or the Low Flow Conveyance Channel. Recruitment is one of the most critical aspects of the demographics of this fish species, and it must be assessed in order to determine why fish are not surviving to reproductive adults at certain times. A number of tools are available by which to assess recruitment including age-growth (otoliths laser ablation), length-frequency (Bhattacharya), survival estimates (from mark-recapture, Ricker curves), population recruitment models (age-structured descriptions), etc. These can be linked to environmental correlates to ascribe survival and recruitment to river conditions.

Response: We agree. Recovery Actions 1.1.3 and 1.1.4 are designed to investigate correlates of survivorship and age-growth relationships.

51. Page 78, § 1.4.4 The statement that "most treated WWTP effluents are not expected to adversely affect aquatic life when that effluent quality meets the water quality limits specified by the EPA" is a concern. If EPA's aquatic life water quality criteria are met, then per se we don't expect adverse effects on aquatic life, unless one assumes that EPA's standards are wrong.

Response: The recovery plan recognizes that there are occasional accidental violations of water quality standards that may adversely affect the silvery minnow. A better understanding of these effects should help direct appropriate management responses.

52. Page 82. Has island destabilization been demonstrated to be beneficial to RGSM? Why is money spent to create or enhance flooded lowlands, but the reverse is done with island destabilization? A huge amount of time and dollars is proposed for habitat manipulations with little, if any, demonstration that such will benefit RGSM. Before promoting actions that have considerable costs (see Section 6.2) and questionable efficacy, much more evidence of value needs to be presented.

Response: We agree that the effectiveness of different habitat restoration techniques have yet to be fully demonstrated. A new Recovery Action (1.2.5) recommends comprehensive monitoring to evaluate the effectiveness of habitat restoration projects.

53. Page 82, 2.1.1: Non native plant removal may be required in some reaches to maintain channel capacity and habitats. Consider on-going efforts for non-native plant removal funded from other sources before dedicating recovery funds to this action.

Response: A wide range of sources will be considered to support non-native plant removal in Big Bend. In fact, the Service is already working with partners in Texas and Mexico to secure funding for this effort. We are collaborating with the World Wildlife Fund, U.S. Geological Survey (USGS), the United States and Mexico Section of the International Boundary and Water Commission, Trans Pecos Water Trust, researchers, and superintendents and managers of six protected areas along the Big Bend Reach of the Rio Grande on a series of collaborative, bi-national ecological restoration efforts in the NEP area. Aquatic and riparian habitat studies and ecological restoration and enhancement projects, including the control of the invasive and exotic Tamarix sp. and Arundo donax, are currently underway within the following seven protected areas in the U.S. and Mexico:

Big Bend National Park (National Park Service, Department of Interior)
Rio Grande Wild and Scenic River (National Park Service, Department of Interior)
Big Bend Ranch State Park (Texas Parks & Wildlife Department TPWD)
Black Gap Wildlife Management Area (TPWD)
Área de Protección de Flora y Fauna Cañon Santa Elena [Secretaría de Medio Ambiente y Recursos Naturales (SEMARNAT)]
Área de Protección de Flora y Fauna Maderas del Carmen (SEMARNAT)
Adams Ranch del Carmen (privately owned conservation area in Texas)

We anticipate continuing to work with land managers and owners and other interested parties, on a voluntary basis, to develop plans to further guide habitat management and control of non-native, invasive species.

54. Page 84, 2.2.2: Plans to modify dam operations and acquire "institutional instruments" (please define) and physical space seems to affirm a persistent, but unproven belief that such will be necessary.

Response: The text has been revised to clarify that each reservoir has operating authorities and regulations, some of which limit opportunities to store water for conservation purposes. Water management will be critical to the recovery of the silvery minnow. Modifications to dam operations (such as the Corps' Cochiti Deviation) have great potential for providing flows that meet the species' life history requirements and should be pursued.

55. Page 84, 2.1.6: Given all the reviews mandated for environmental compliance and permitting, why does the plan recommend additional review of in-stream projects?

Response: The second sentence of explanatory text has been removed to clarify that no new mandates were intended.

56. Multiple conflicting comments were received regarding the phrase "within existing authorities." Some commenters asked that it be removed noting that recovery options will be

extremely limited if existing authorities cannot be modified. Others suggested that any changes to existing authorities would be undesirable. Specifically, it was emphasized that in the case of tribal rights there are specific trust obligations of the United States to tribes under federal laws, contracts, and the trust duty. A final comment encouraged more consistent application of the term throughout the section.

Response: We agree that the term 'within existing legal authorities' is used inconsistently and in some cases, in a manner that contradicts the intent of particular recovery actions. This section has been revised to recommend that all possible water management solutions be considered while noting that existing laws and authorities may limit certain options. Additionally, language has been added to emphasize the rights of tribes and the responsibility of the United States to tribes under federal law.

57. Page 85, 2.2.4: While the MRGCD can and does encourage increased water efficiencies and conservation practices for agricultural water use, we cannot support the concept of agricultural forbearance. There are a number of practical considerations for this opposition. Checker-boarding type acquisitions (most likely) yield only very small quantities of water and are fraught with management difficulties. Forbearance at a lateral or main canal level is less problematic from a management standpoint, but would involve the unanimous agreement of (in most cases) hundreds of landowners. Only about 1/4 of the annual flow of the Rio Grande originates on the Rio Chama. So, forbearance of agricultural water delivery does not necessarily translate into an equivalent volume of storage at either El Vado or Abiquiu reservoirs, and storage at Cochiti reservoir is currently not an authorized use of that facility.

    Forbearance, if it did happen on scale large enough to both be practical, and do any good for the RGSM, would likely hasten the conversion of agricultural lands to urban and residential development. Water use would not decrease, and might possibly even increase on such lands. The source would likely shift to groundwater withdrawal, ultimately translating to increased river losses, leading to zero net increase in water available for RGSM.

    The focus of water acquisition, if any, should not be restricted to the middle valley. There is significant use of water, perhaps equaling or exceeding middle valley use, in the northern half of the state. And, though it gets more complicated due to the Rio Grande Compact, there is water consumption in both Colorado and Texas, which has an impact to the available water supply for the RGSM.

    Finally, there is an existing mechanism for the acquisition of water. There currently exists an open water market. Although MRGCD does not like to see agricultural water transferred to other uses, there is nothing to prevent the program from purchasing water rights from willing sellers. Suggestions of forbearance programs appear to be an attempt to make an end-run around this market.

    Response: The team recognized that some recovery actions may be politically or legally challenging and some may require significant public discussion. Actions that have the potential to affect existing water rights clearly fall into this category. Prior to any

implementation of forbearance a comprehensive discussion and resolution of the issues raised above would be necessary.

58. Page 88, Recovery Action 2.3.6: All major surface water diversions and returns and groundwater withdrawals and use within the middle Rio Grande are currently metered.

    Response: It is unclear what is meant by "major." The State Engineer has publicly stated that comprehensive metering in the middle Rio Grande is incomplete and necessary to allow for Active Water Resource Management (J. D'Antonio, State Water Plan Public Meeting, 5/7/09).

59. Page 90, § 3.1.4.3 "Determine the role of environmental parameters in sex determination of Rio Grande silvery minnow": A technical justification is not presented for this action. It is stated that "Temperature has been demonstrated to be a factor responsible for determining sex during embryonic development of several species. If this is true with Rio Grande silvery minnow, there may be a need to reassess some conservation strategies." The meaning of this statement is unclear, yet the draft plan proposes to spend $150,000 over 3 years to make this determination. The temperatures at which this species spawns and incubates are well known and should be the temperatures used for propagation. We recommend deleting this action.

    Response: The role of temperature in sex determination has not been evaluated in the silvery minnow and modified water temperatures are a likely consequence of climate change. If temperature has the potential to affect sex ratios in the wild, there may be serious demographic consequences. It should be noted that the cost is an estimate.

60. Page 105, Table 1. Threats Tracking Table: There is considerable overlap and redundancy in the list of threats for each of the five listing factors. The threats should be specific to that listing factor. For example, "Increase in non-native and exotic fish species" should be listed as a threat under listing factor "C. Disease or predation." Including nonnative species as a threat under listing factor A is confusing and redundant.

    Response: This list follows directly from Section 1.7 which summarizes the reasons for listing based on the threats assessment contained within the listing package for the silvery minnow (U.S. Fish and Wildlife Service 1994). The severity of predation and disease due to non-native and exotic fish species (Listing Factor C) is also a function of habitat modification (Listing Factor A).

Implementation Schedule

61. FWS should clarify what party is best suited to implement recovery actions regarding captive propagation. On the other hand, the recovery actions also call for the development of a "plan to guide captive propagation," recovery plan at 89 (action 3.1.1), implying that one is not already in development.

    Response: The U.S. Fish and Wildlife Service is the appropriate lead agency for captive propagation activities. The text has been changed. Also, a note has been added to the action

to indicate that the captive propagation plan is complete, but implementation and updates to the plan are expected until recovery is complete.

62. All priority 1 actions are continuations of ongoing research, management, and monitoring activities. Not a single priority 1 action will directly benefit or improve status or RGSM. No actions to address water operations and provide water for RGSM are included within priority 1 or 2 actions. And this is done knowing that dewatering and water diversion are the 2 primary threats to RGSM within currently occupied range. In fact, the vast majority of actions that would have a direct and positive impact on RGSM are all listed as Priority 3. Fully $45.6m will be spent on habitat manipulation without any solid evidence that doing so will have any positive effect on RGSM. Many of the actions identified should occur regardless of whether a federally-protected species is present or not. This action 2.2.2.3 should be elevated to a Priority Level 1 or 2 because it is the overriding issue in the middle Rio Grande according to recent U.S. Fish and Wildlife Service biological opinions. This is also true of actions 2.2.2.4, 2.3.3.2, and 2.3.5.

    Response: Priority 1 actions are those critical to preventing extinction. The recovery team assigned this priority to captive propagation, monitoring, and genetics management only. However, effective water management in the middle Rio Grande is critical to alleviate jeopardy in the wild and provide for the conservation of the species. These actions have been changed from Priority 3 to Priority 2.

63. Page 113, 6.2 Implementation Schedule - Action 1.1.3: Actions such as this one on recruitment should be a higher priority, but it should have additional elements on species demographics. There needs to be a better understanding of population age and structure in order to better understand the causes for failed survival and recruitment of the species.

    Response: Action 1.1.3 (priority 2) is aimed at understanding the ecological correlates of survival and recruitment. The text has been revised to improve clarity.

64. Page 113: Actions 1.2.2 and 1.2.3 appear to overlap considerably and should have a priority of 3, not 2. What is meant by discharge "amplitude"?

    Response: These actions have been combined to reduce redundancy and the text clarified. However, since information about stream flows to support all life stages of the Rio Grande silvery minnow would be needed to achieve actions that would provide for full recovery, the priority level has not been changed.

65. Action 1.5.3 will not lead to any clear-cut evidence regarding the flow regime and recovery. Efforts here would be better placed into non-native removal.

    Response: We disagree. We expect that certain habitat conditions will be found to favor non-native species. Removing non-natives in the absence of habitat change is unlikely to be successful over the long term. This action recommends research that will improve our understanding of how flow influences habitat conditions for non-native species likely to negatively affect the silvery minnow.

66. Page 114: Actions 2.1.1 and 2.1.2 appear to overlap considerably and should be given a priority of 1, not 2.

Response: The Actions have been combined. Since these actions would be implemented for reintroduction areas, by definition, they cannot be Priority 1. The text has been clarified to note that these actions would occur outside the middle Rio Grande.

67. Implementation Schedule. The costs of recovery are inappropriately and disproportionately assigned to the Middle Rio Grande. In addition, it is inappropriate to assume that the Middle Rio Grande Collaborative Program will be responsible for recovery efforts outside of the Middle Rio Grande.

Response: The Implementation Schedule identifies the agency or partner most appropriate to carry out a particular recovery action. The MRGESCP has identified, through their long-term plan, many of the actions also contained in the RGSM Recovery Plan. For this reason, the recovery team recognizes that the collaborative program is group best suited (both in terms of expertise, interest, and potential funding) to support many of the recovery efforts in the middle Rio Grande. The plan has been revised to identify the U.S. Fish and Wildlife Service as the lead party for implementing actions outside the middle Rio Grande.

68. Most of this version of the RGSM recovery plan reads as a conservation plan for RGSM in the middle Rio Grande of New Mexico. Rather, this should be a recovery plan for the species throughout its historical range. The most likely locations identified for reestablishment are Texas and yet the draft plan does not include the State of Texas in the implementation schedule and very little money is estimated as necessary for FWS or other entities to engage in the reestablishment actions in Texas or even in the Pecos.

Response: A smaller number of tasks are necessary to reestablish the silvery minnow in its historic range than to recover the species within the middle Rio Grande. These tasks are in no way considered less important, but because there are perceived to be fewer threats in the historic range, fewer steps were deemed necessary to reestablish the species. The State of Texas and IBWC have been added to additional tasks in the Implementation Schedule.

69. The cost estimates do not include the likely costs of water acquisition in the middle Rio Grande.

Response: A task for water acquisition and its associated costs have been added to the plan.

70. In the middle Rio Grande, reestablishment potential in the Rio Grande above Cochiti Lake is described being low because of marginal habitat on the river reaches evaluated which did not include Pueblo reaches. If this reach is truly not in the top areas to be prioritized in the recovery plan, should the MRGESCP continue to spend scarce funds on habitat and habitat enhancement for Rio Grande silvery minnow in this area?

Response: The recovery plan does not set priorities for the MRGESCP. The recovery team acknowledges that habitat above Cochiti may not currently provide for all life stages of silvery minnow although limited access to private and tribal lands suggests our understanding of the reach is incomplete. What is also unknown is how habitat restoration might improve silvery minnow habitat in this area. Additional information from the Service's assessment of habitat above Cochiti Lake has been added to the plan.

71. Finally, the technical rationale for how the Rio Grande from Elephant Butte Reservoir to Presidio could be considered a higher priority reach for recovery than the reach above Cochiti Reservoir is unclear.

    Response: The technical rationale for the potential reintroduction sites is listed and discussed in the introductory material in Appendix G. While there may be some disagreement on the specific ordering of the potential reintroduction sites, there was agreement that both the reach above Cochiti and the reach between Elephant Butte and Presidio had low potentials for reintroduction. The Service has concentrated their efforts on those sites with higher potentials for reintroduction success.

72. Appendix F regarding the reestablishment potential in the "Rio Grande Above Cochiti Lake" -- The sentence in the first paragraph of that section states that "there will be average increases in population growth and increased use of groundwater but this will require transfer of existing water rights to offset these uses" is inaccurate with respect to the three Pueblos in that reach. The Pueblos have aboriginal water rights which are vested, recognized, and protected under federal law, but which may not be currently in use. Exercising those rights does not require any transfer of existing rights as offsets. This should be corrected or qualified.

    Response: The text has been corrected and clarified as recommended.

    Appendix F. The discussion of the fish community within the Cochiti Reach (Cochiti to Angostura Dam) should be revised to indicate that silvery minnow have not been observed in this reach since 1995?

    Response: This information has been added to Appendix F and Section 1.5.1.

APPENDIX K
COMMENTS ON THE 2009 DRAFT REVISED RECOVERY PLAN

Response to Comments
Rio Grande Silvery Minnow
Draft Revised Recovery Criteria

In response to numerous comments on the recovery criteria presented in the revised Rio Grande Silvery Minnow Recovery Plan released in 2007, the recovery team developed objective, measurable criteria that could be evaluated using a Population Viability Analysis (PVA) for the species.

On April 9, 2009, the Service released revised criteria and a new appendix to the recovery plan that described the preliminary PVA model for the Big Bend experimental 10(j) population. These documents were available for review for 45 days – from April 9 to May 26, 2009. Comments were solicited from the public through a Federal Register notice; via email distribution lists; in news releases; and on the Service's New Mexico Ecological Services Field Office website. The Service also mailed copies of the draft revised criteria and Appendix to the Governors of the 13 Rio Grande Pueblos and solicited peer review from the 3 reviewers who had previously commented on the plan. The following summarizes comments received and the resultant edits to the recovery plan.

PEER REVIEW COMMENTS

We requested review of the plan by Dr. Anthony Echelle, Oklahoma State University; Dr. Keith Gido, Kansas State University; and David Galat, USGS/University of Missouri and received comments from Anthony Echelle and Keith Gido. Comments and responses are presented below.

Anthony Echelle

1. The demographic criteria for preventing extinction and allowing downlisting seem well-conceived and appropriate. I wholeheartedly agree that the demographic criteria are "overarching," and that achieving these criteria will, by definition, require reducing the threats. In other words, several self-sustaining wild populations are much better than numerous artificially maintained populations for the long-term success of the species. I have no suggestions for improvement, given the logistic problems of achieving the goals outlined (of course it would be better to have more self-sustainable populations, etc.). Achieving the described goals would go a long way toward preserving the species.

   Response: Response not required.

2. My one quibble point is that I doubt that the species will ever be delisted unless human projects and population growth in the region are reduced and this is not likely to happen anytime soon.

Response: We agree. The recovery plan assumes full recovery will take 30 or more years to achieve.

3. The PVA analysis seems expertly done. It seems to thoroughly incorporate the available information on the species. I have no other comments other than to laud the effort to model the effects of alternative management strategies on the probability of extinction.

   Response: Response not required.

Keith Gido

1. Distributional status. I was pleased to see an emphasis on the occurrence patterns of RGSM throughout the system rather than population estimates of any individual region. Monitoring for this should be robust and increased spatial distribution will likely reflect the status of the species in the system.

   Response: Response not required.

2. Population Viability Analysis. I appreciate the use of a population viability analysis to help develop the stocking criteria for the reintroduced population of RGSM in the Big Bend area. Your team has done a nice job explaining the assumptions of the model. You also have correctly cited the limitation of using such a model to guide management decisions regarding endangered species, as there is little evidence that models can accurately predict fluctuations of natural populations of stream fishes, particularly warm-water fishes in dynamic prairie streams. Regardless of this acknowledgment, it appears that the models will be used to evaluate the recovery of the species (e.g., Recovery Criteria 2-A-3, 2-B-1, 3-A-1).

   Response: The models will be used to estimate the extinction risk for reintroduced populations. This value would represent a long-term average risk rather than a precise prediction of annual fluctuation. The model will be used to formalize our assumptions about the species and the ways it might respond to different management (such as different stocking rates), and as a tool to test those assumptions. As information is refined, the model can be further refined.

3. It seems that it would be helpful to clearly separate how the PVA assessment will be used to 1) evaluate the stocking rates in a reintroduced population and 2) evaluate the probably of extinction of other populations. The consequences of failure are quite different for these two scenarios. Moreover, it seems necessary that the first criteria would be to evaluate the recovery team's ability to predict population vital rates (e.g., reproduction and recruitment) as a function of environmental fluctuations. Developing static rates and then randomly allowing those to fluctuate will not be nearly as powerful as understanding of how they vary with environmental conditions. If these relationships cannot be rigorously established, then population growth rates would be highly suspect. Unfortunately, these data are difficult to get and typically required many years of sampling under different environmental conditions. Perhaps through an adaptive management scenario such a database could be established.

Response: The PVA assessment will be used to both determine stocking rates, and over the longer term, as information about the reintroduced population becomes available evaluate its extinction risk (and associated progress toward recovery). We do not envision using the PVA model as currently parameterized for any other population than the one at Big Bend. Other models of similar form, but different demographic values and assumptions, may be developed or used for other populations as they become established. We agree that relationships between population growth and different environmental variables are difficult to establish without many years of data. Data collection efforts are already underway for the Big Bend population. We agree that adaptive management will be central to improving our knowledge about the response of the species to different conditions. The recovery plan recommends such an adaptive process be used throughout the recovery program.

4. Giant river cane analysis. The PVA of the giant river cane provided an interesting hypothesis. However, these results are not very compelling without empirical data to support those trends. Moreover, there was no indication of error or uncertainty in Figure 1, which I assume would be quite large and may suggest the two modeled scenarios are not different. In general, it was not clear what role this analysis played in the document.

   Response: We agree. The giant river cane analysis is entirely hypothetical at this point. Ecologists on the region believe that giant cane is and will be a significant agent of habitat change but the trajectory of that change and the relationship of increasing cane to habitat availability for the species will require field evaluation and testing. We have added error bars to Figure 1.

PUBLIC REVIEW COMMENTS

The Service received 4 comment letters identifying a total of 12 significant issues which are presented and responded to below.

1. Comments were received noting that the PVA model, presented for review, does not represent the best available science because our understanding of Rio Grande silvery minnow biology is constantly changing.

   Response: We agree that information about the biology and ecology of the silvery minnow is likely to be refined over the period anticipated for recovery (approximately 30 years). We disagree, however, that the PVA in Appendix H does not rely on the best available science. We built the model using what is currently known about the species in its occupied range. The population's demographic characteristics in Big Bend are currently unknown. For this reason, the plan's recovery criteria rely on extinction risk rather than any particular demographic values or population growth rates. This leaves open the possibility that models and their input values will be refined through time. The PVA presented in Appendix H is provided as an example of the type of analysis that could be used to evaluate a species' extinction risk. The model is presented as preliminary, with an explicit acknowledgement that changes in understanding will lead to revisions in model inputs over time. Text has been added to the criteria and to the Appendix to improve clarity on this point.

2. Concerns were expressed that there was inadequate review because only the recovery criteria were available for comment.

   Response: The Service carefully considered whether to resubmit the plan for review and determined that only the changes to the recovery criteria constituted a substantial change. Changes to the main text were largely updates and revisions to reflect emerging knowledge and information. The overall plan, however, is similar to the previously submitted document. The recovery team, which included a stakeholder group representing all affected parties in New Mexico and Texas, and a tribal subteam was consulted on this approach. The teams agreed that releasing only the criteria and relevant supporting documentation was appropriate and that further public review of the main document and the associated delay in finalizing the plan was not warranted.

3. Comments were made that the model presented for peer review is not the only possible Rio Grande silvery minnow PVA model and that other models may be superior to the one presented.

   Response: We agree. Models are merely tools and multiple tools are likely to help evaluate progress toward recovery. The RAMAS Metatpop platform can be used to develop multiple different models depending on values used for different demographic parameters and the assumptions used for different demographic drivers. Other model platforms may also be used. The Service does not anticipate using the model presented in Appendix H in its current form to evaluate progress toward recovery. See response to comment 2 above.

4. Objective 1-A does not define any specific criteria for extinction risk.

   Response: The objective has been reworded to clarify that the criteria relate to distribution and annual reproduction only.

5. Criteria 1-A-2 does not specify if the factor sufficient to lead to delisting is the existence of annual reproduction (i.e. a single young-of-year individual minnow), a specific raw number of documented annual reproduction instances, a per capita rate of reproduction, or a certain geographic density of reproduction.

   Response: Criterion 1-A-2 does not apply to delisting, only to preventing extinction. While it would be unlikely to find only one young-of-year silvery minnow in any given year evidence of a single young-of-year silvery minnow would be sufficient to determine whether the species was reproducing. The text has been revised for clarity.

6. Recovery criteria 2-B-1 is premised on a relationship between base flows, habitat sufficiency, and survival rates that were not included in the PVA model presented in Appendix H.

   Response: We agree that these relationships were not fully explored in the modeling exercise. Indeed, the PVA discussion provided for public and peer review acknowledges that

information about habitat availability, carrying capacity, and species behavior in the Big Bend reintroduction area is limited and is by definition likely to increase over time. As information becomes available it will be incorporated and the PVA model should be revised.

7. The draft revised criteria failed to account for climate change. The PVA Appendix should include, in addition to the other questions, the following: "how does population viability change under current and changed climate conditions."

   Response: We agree that information about climate change should be included in the PVA model as it becomes available (see above). The revised recovery plan has included climate change research made available in recent years. We revised the language in Appendix H as recommended.

8. Criteria 2-A-1 and 2-A-2 should include the term 'consecutive' in order to avoid an interpretation that would allow the sum of any 5 favorable years, whether in a 5, 10, or 20 year period, to meet the criteria.

   Response: The recommended change has been made.

9. It appears that Recovery Criteria 1-A-1 requires documentation of silvery minnow at 3/4 of the monitoring sites within each reach while 1-A-2 and 2-A-2 require documentation of young-of-year at 3/4 of the monitoring sites over the entire middle Rio Grande without regard to reach. These differences should be reconciled.

   Response: The intent was to meet the criteria at 3/4 of the sites per reach. The text has been corrected.

10. Clarification is needed about whether the PVA model presented for review was intended for reintroduced populations, extant populations, or the Big Bend reintroduction population only.

    Response: The PVA presented for review was intended to represent the state of knowledge about the Big Bend reintroduction area, identify knowledge gaps, and to illustrate how a PVA might be developed for other reintroduction areas, or for extant populations. The model, as currently presented, applies only to the Big Bend program. It is anticipated that the model will evolve as knowledge about the system improves, and that a different model would need to be developed to describe other populations. Text has been clarified.

11. The PVA model is incorrect because it ignores a growing consensus that up to 4% of the silvery minnow population lives to Age 3 or more and likely provides a significant "bridge" population in the event of two or more years of poor minnow reproduction.

    Response: The revised recovery plan discusses the hypothesis that large numbers of silvery minnow live longer than 2 years and that studies may be underway soon to test it. Should evidence emerge to substantiate this theory, and it seemed appropriate to extrapolate that evidence to the Big Bend population, the PVA model would need to be revised to incorporate older age classes. Additional data would need to be acquired to determine whether

reproductive rates of these older fish would affect long-term growth trajectories for any given population.

12. A discussion of nursery habitat should be added to the PVA Appendix along with a description of observed channel changes following the 2008 flooding in the Big Bend reach.

    Response: Additional text and citations have been added to the PVA Appendix along with references to habitat descriptions in the main document. Analyses of geomorphic trends and estimates of available habitat in the Big Bend are currently being revising following the 2008 flooding events.